ENGINEERING CASE LIBRARY

ECL 93A

Design of a Compact Air Driven Impact Wrench at Skil Corporation (A)

In March of 1962, Mr. Frank Kaman, Vice President in charge of Engineering and Research, discovered what he considered to be a need by auto mechanics for a small, light weight, high torque, "under the hood" impact wrench. As Frank explained it, "I was turning into my driveway when my car sputtered and died. I suspected it was a fuel problem as the car had been acting up for several days. I found the fuel pump mounting bolts were loose and had one heck of a time using standard mechanics' wrenches to tighten them. At that time our company was manufacturing large impact wrenches of the kind used by garages and service stations for heavy applications, such as removal and tightening of wheel lug bolts. However," Frank continued, "this wrench was too big to be used in many confined places under the hood such as mounting and demounting a fuel pump."

This case was prepared by Professor Richard Thompson of Purdue University and Professor Robert Wickham of Ohio University during the 1967 Summer Institute on Case Methods supported by the National Science Foundation at the University of Illinois. The cooperation of Frank A. Kaman, Peter G. Rebechini, Elmer F. Etzkorn and J. Chris Green of Skil Corporation is gratefully appreciated.

Skil Corporation began as a company called Skilsaw Incorporated, and had its beginning in a one room loft on the corner of Grand Avenue and St. Clair Street in downtown Chicago in 1924. Its first product was a portable electric saw which at that time was the only tool of its kind on the market. So popular did Skilsaw become that as competitors put similar portable electric hand saws on the market the general public referred to all such saws as "Skilsaws".

From this modest beginning in 1924, Skil Corporation in 1966 had sales of over $48,000,000 with profits of over $3,600,000. It has become a well integrated manufacturer of a broad line of portable electric and pneumatic tools of all types. The company has a sales force of over 150 salesmen selling to over 5,000 distributors, and maintains fifty company owned and operated repair stations. Outside of the United States, Skil has three manufacturing plants and similar sales and service networks. The air tool and portable equipment plant has about 1,200 employees including seventy engineers and 20 draftsmen.

In June of 1962, the project for the design of a small impact wrench, later to be known as the "Imp", was started. Emory Hall, head of Special Projects Design, was assigned to guide the Imp project through its beginning stages. Peter Rebechini, Chief Engineer Air Tool Design, explained the start of the design project in this manner. "Of course air tools were not exactly new to us, we have been making them for many years (Exhibit A-1). Our problems on the Imp were that it must be extremely small, very light and have a high torque. At this stage we did not know if it was possible to arrive at all of these conditions. For example, one of our large air motors could not be just scaled down as air motors are not linear. The same applies to the impact mechanism. So our problem was to 'wed' a new motor, impactor and case into a single device."

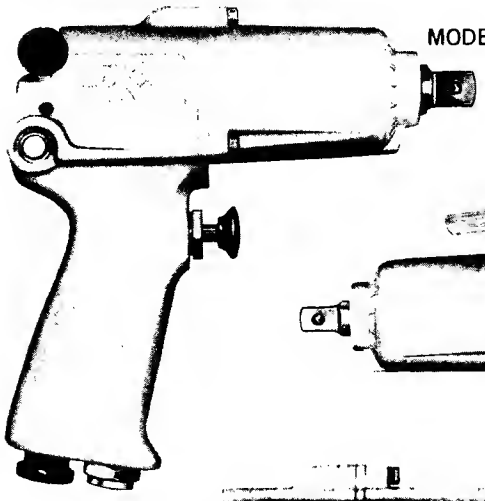
It is more or less standard procedure in the design of hand held power tools to begin by making wood or plaster models and by a process of trial and error make it fit the hand as well as contain the internal mechanisms. At Skil a wooden prototype was made and modified using modeling clay to add features or cut away the wood to remove areas. Such models are quite substantial and can have actual chucks, triggers or other controls mounted to them. An important feature of a good hand tool is balance - how the weight and center of gravity are arranged to "feel good" in the hand. Slugs of metal were located inside the model to simulate the position and weight of internal parts. This enabled the designers to arrive at the best combination among weight, balance and hand hold.

As soon as the preliminary shape and size had been established, and while small refinements were being made, drawings were prepared so that the impactor and air motor specifications could be determined. Mathematical calculations indicated that it was possible to have an air motor and impactor fit into the housing of the prototype. Now it was necessary to have the model shop actually make an impactor and motor for testing. Quite often two devices made and tested separately do not behave properly when connected together. This is due in part to the fact that one device induces certain loads on the other that could not be determined in advance. Pete said that the impactor was by far the most difficult part of the Imp to develop because of its size (See Appendix A-1). Two parts in particular gave trouble. They were two cylindrical cams that operated on a common axis and faced each other. The model shop was able to make them but the cams could not be made rapidly in large quantities. This problem almost caused the entire Imp project to be dropped. Fortunately in the search for an economical method of making the cams the idea of a steel investment casting was tried - and it worked! The investment casting process uses an expendable pattern of the part to be cast. This pattern is dipped

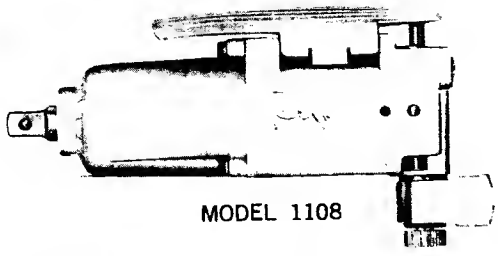
into a slurrylike mixture which hardens to form the mold. The mold is then heated; this makes the mold harder and melts the pattern which is made of wax or frozen mercury. This casting process eliminates the need for many machining operations because of the smooth surface finish obtained and the close tolerances that can be held.

Now all that remained was to determine the best place to attach the air hose, the type and location of an off-on control, the location of a forward and reverse control, and the type of air bleed control to vary the torque.

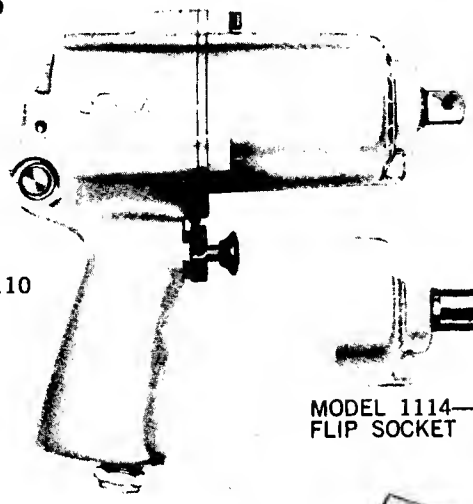
SKIL AIR IMPACT WRENCHES



MODEL 1105

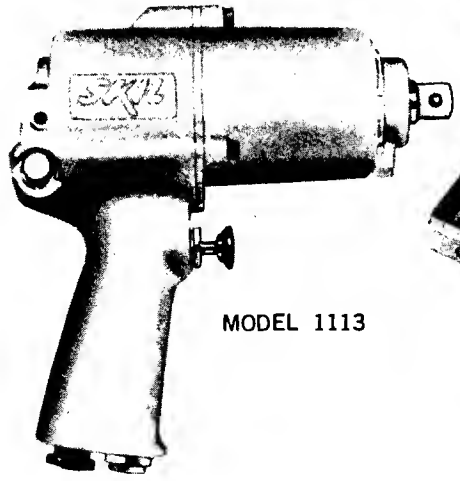


MODEL 1108

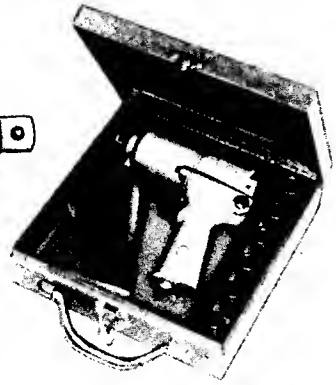


MODEL 1110

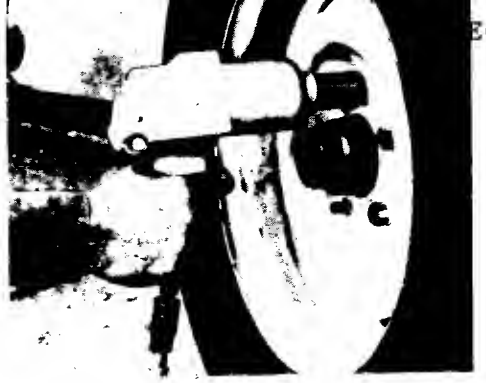
MODEL 1114—INCLUDES FLIP SOCKET



MODEL 1113



MODEL 1112



ECL 93A

3/8" SQUARE DRIVE—COMPACT—MODEL NO. 1105
Newest addition to the Skil line of wrenches. Compact for getting in those hard to reach places, yet powerful enough to make fast work of tough jobs. The light weight of this model, only 3 3/8 pounds, makes it easy to use without tiring. Jobs are completed faster and work hours are more productive

1/2" SQUARE DRIVE—COMPACT—MODEL NO. 1109
Has the same features and specifications as MODEL 1105 except it has a 1/2" square drive. (Not Pictured)

3/8" SQUARE DRIVE—COMPACT—MODEL NO. 1108
Here's a small, lever throttle wrench with big power. Weighs only 3 pounds and works in confined areas, where ordinary wrenches cannot fit. It has the same patented "Balanced Blow" impact mechanism found in Skil's other air wrenches. This assures full power impact and minimum "kickback."

1/2" SQUARE DRIVE—HEAVY-DUTY—MODEL NO 1110
This hefty, power packed wrench is designed for fast driving and will even remove "frozen" nuts and bolts. Specially built-in mufflers give smooth, quiet performance. Equipped with Skil's exclusive dual throttle for accurate fingertip power control. See opposite page for complete details on the dual throttle.

1/2" EXTENDED SPINDLE—HEAVY-DUTY—MODEL NO. 1114
Has the same features and specifications as MODEL 1110 except has a 2" extended spindle for hard-to-reach areas and comes with No. 24362 Flip Socket.

AIR IMPACT WRENCH KIT—MODEL NO. 1112
Includes MODEL 1110 Wrench shown above; six hex sockets (see specifications below); leather boot and steel carrying case.

5/8" SQUARE DRIVE—HEAVY-DUTY—MODEL NO. 1113
Another husky wrench with the power and capacity for doing a variety of extra heavy-duty jobs. Capable of handling a 3/4" bolt, this wrench starts where the others leave off. Powerful "Balanced Blows" quickly drives or removes nuts, bolts, studs and screws.

SPECIFICATIONS

model no.	square drive	blows per minute	free speed r.p.m.	air inlet size	torque ft. lbs.	recommended hose size	length to shoulder	net wgt. lbs.	ship. wgt. lbs.
1105	3/8"	800	11,000	1/4"	100	5/16" I.D.	5 3/4"	3 3/8	5 3/8
1109	1/2"	800	11,000	1/4"	150	5/16" I.D.	5 3/4"	3 3/8	5 3/8
1108	3/8"	800	11,000	1/4"	100	5/16" I.D.	6 3/16"	3	5
1110	1/2"	800	8,700	1/4"	300	5/16" I.D.	6 3/4"	5 7/8	7 3/4
1114	1/2"	800	8,700	1/4"	300	5/16" I.D.	6 3/4"	6 1/4	8 1/4
1113	5/8"	675	6,500	1/4"	450	5/16" I.D.	6 3/4"	6	8

EQUIPMENT:
Model 1112 kit includes Model 1110 wrench in No. 24344 steel carrying case and one each of the following accessories:

No. 6521 1/2" Hex Socket
No. 6522 9/16" Hex Socket
No. 6524 5/8" Hex Socket
No. 6525 11/16" Hex Socket
No. 6526 3/4" Hex Socket
No. 6528 13/16" Hex Socket
No. 24342 Leather Boot

Impacting Mechanism of 1120 Air Impact Wrench by Skil Corporation

The impacting mechanism used in the "Imp" is basically the same as that used in the larger Skil air impact wrenches (Exhibit A-2). It consists of a housing which is driven through bevel gears (Part Numbers 27881 and 27882) by the air motor; and a set of cams that causes the jaw pins (#27893), which rotate with the housing, to move up and down at the proper points during the cycle. The housing and cams rotate about the anvil (#27891) which is struck by the jaw pins. The wrench's output is the rotary motion of the anvil, and the attachments are connected to the anvil.

The housing, which rotates continuously, is made up of the driver cover (#27885) and the hammer housing (#27886) which are fastened together. The set of cams consists of an upper cam (#27889) which in effect is pinned to the anvil, but allowed to rotate a limited number of degrees as determined by pie shaped recesses in the upper side of the cam; an intermediate cam (#24660) which is allowed to move axially along the anvil and is free to rotate; and a lower cam which is constrained to rotate with the hammer housing, but it can also move axially along the anvil. The two jaw pins (#27893) are attached to the lower cam and therefore the movements of the jaw pins are those of the lower cam.

Now let us consider the operation of the impacting mechanism when the air motor is rotating very slowly, as for example if the motor were being turned by hand. The driver cover and hammer housing would therefore be turning very slowly, and let us assume that the rotation is in the clockwise direction. Then the lower cam, which is rotating with the hammer housing, will engage the intermediate cam along a no-slip surface, causing the intermediate cam to rotate with the lower cam. Consequently, the intermediate cam will contact the upper cam along a ramp surface. If the anvil is prevented from turning, the ramp surfaces will slide over one another, forcing the intermediate cam, the lower cam, and the jaw pins down. When the upper and intermediate cams have slipped until ramp surfaces disengage, a pair of springs (#29356), which are located between the lower cam and the hammer housing, push the lower cam up.

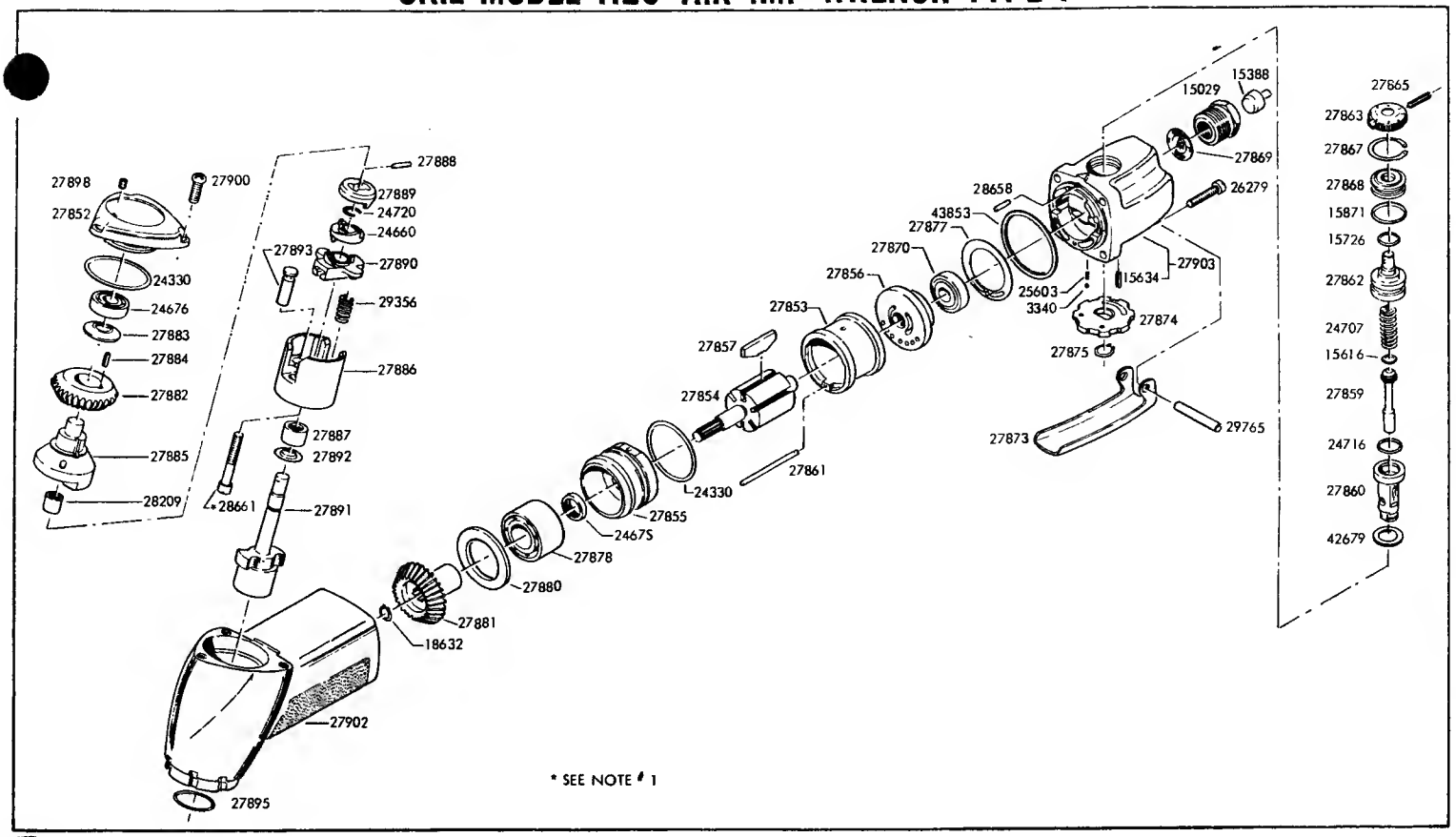
If the motion were considered to be linear, it could be described as shown in Exhibit A-3. Exhibit A-3 represents the motion of the jaw pin with respect to the anvil for one revolution. It should be noted that the jaw pin will not contact the anvil when the angular velocity of the hammer housing is small, i.e., the angle ϕ will be approximately ninety degrees. However, as the velocity of the housing is increased, the jaw pin will come closer to striking the anvil; therefore the angle ϕ in Exhibit A-3 will become larger as the angular velocity is increased. This is due to the fact that the time required for the jaw pin to be retracted is constant; it is prescribed by the spring rate and the mass of the jaw pin and lower cam. But, the time required for the hammer housing to rotate far enough to allow the jaw pin to contact the anvil will be decreased as the rotary speed is increased. Thus the speed of the housing will reach a point at which the spring will not be able to retract the jaw pin before it strikes the anvil. When the jaw pin strikes the anvil, it imparts a pulse of torque to it and the rotary motion of the hammer housing will either be momentarily stopped or stopped and reversed due to rebound off the anvil. Then the jaw pin is retracted fully and the rotating parts again start to pick up speed. The torque output of the wrench therefore depends upon the angular momentum of the rotating mass and the distance that the anvil moves upon impact.

The lower cam has on its upper face two raised camming surfaces located at different radii from the axis of the anvil and the intermediate cam has on its lower face two raised camming surfaces which are located at radii corresponding to those of the lower cam. When the motion of the impacting mechanism is in the clockwise direction the lower cam will contact the intermediate cam and both inner no-slip surfaces (located at the smaller radiis) engage. The outer no-slip surfaces also engage. The engagement can occur only once and is maintained as long as the motion is in the clockwise direction.

Similarly, the upper cam has two raised surfaces on its lower face which are located at different radii and the upper face of the intermediate cam has two raised surfaces located at radii corresponding to those of the upper cam. When the rotary motion is in the clockwise direction, the intermediate cam will engage the upper cam along both corresponding ramp surfaces. Thus since there are two offset ramp surfaces on each cam face, the jaw pin will be extended once during each revolution as indicated by the broken line in Exhibit A-3.

When the rotary motion of the mechanism is reversed (counterclockwise rotation), the relative motion of the parts in the mechanism is basically the same; however, the manner in which the cams engage is reversed. The upper and intermediate cams will now engage along no-slip surfaces, while the intermediate and lower cams will engage along ramp surfaces. The jaw pins will now be forced down at the same relative points in the cycle as those occurring in clockwise rotation. This angular shift is determined by permissable radial movement of the upper cam due to the pie shaped recesses for the pin.

SKIL MODEL 1120 AIR IMP WRENCH TYPE 1



* SEE NOTE # 1

SKIL MODEL 1120 AIR IMP WRENCH TYPE 1

PART NO.	PART NAME	NO. USED
3340	BALL	1
15029	REDUCER BUSHING	1
15388	PIPE PLUG	1
15616	"O" RING	1
15726	"O" RING	1
15871	"O" RING	1
18632	RETAINING RING	1
24330	"O" RING	2
24660	INTERMEDIATE CAM	1
24675	OIL SEAL	1
24676	BALL BEARING	1
24707	SPRING	1
24716	"O" RING	1
24720	RETAINING RING	1
25603	SPRING	1
26279	SCREW	4
27852	MECHANISM COVER	1
27853	CYLINDER BUSHING	1
27854	ROTOR	1
27855	FRONT END PLATE	1
27856	REAR END PLATE	1
27857	ROTOR BLADE	6
27859	THROTTLE VALVE	1
27860	REVERSING VALVE	1
27861	DOWEL PIN	1
27862	AIR REGULATOR	1
27863	REGULATOR KNOB	1
27865	ROLL PIN	1
27867	RETAINING RING	1
27868	REGULATOR COVER	1
27869	FILTER	1
27870	BALL BEARING	1
27873	THROTTLE LEVER	1

PART NO.	PART NAME	NO. USED
27874	REVERSING KNOB	1
27875	RETAINING RING	1
27877	GASKET	1
27878	BALL BEARING	1
27880	SPACER	1
27881	PINION	1
27882	GEAR	1
27883	SPACER	1
27884	KEY	1
27885	DRIVER COVER	1
27886	HAMMER HOUSING	1
27887	NEEDLE BEARING	1
27888	CAM PIN	1
27889	UPPER CAM	1
27890	LOWER CAM	1
27891	ANVIL	1
27892	THRUST WASHER	1
27893	JAW PIN	2
27895	"O" RING	1
27898	SET SCREW	1
27900	SCREW	3
27902	MOTOR HOUSING ASSEMBLY	1
27903	THROTTLE HEAD ASSEMBLY	1
	15634 ROLL PIN	1
28209	NEEDLE BEARING	1
28658	DOWEL PIN	1
28661	SCREW	2
29356	SPRING	2
29765	ROLL PIN	1
42679	WASHER	1
43853	SQUARE RING SEAL	1

SERIAL NUMBER

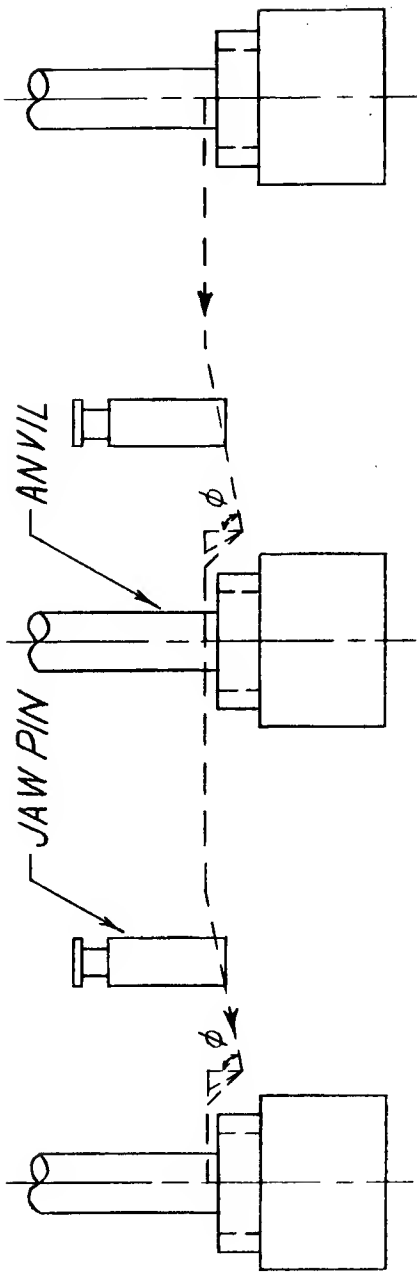
D - 119000 -- UP

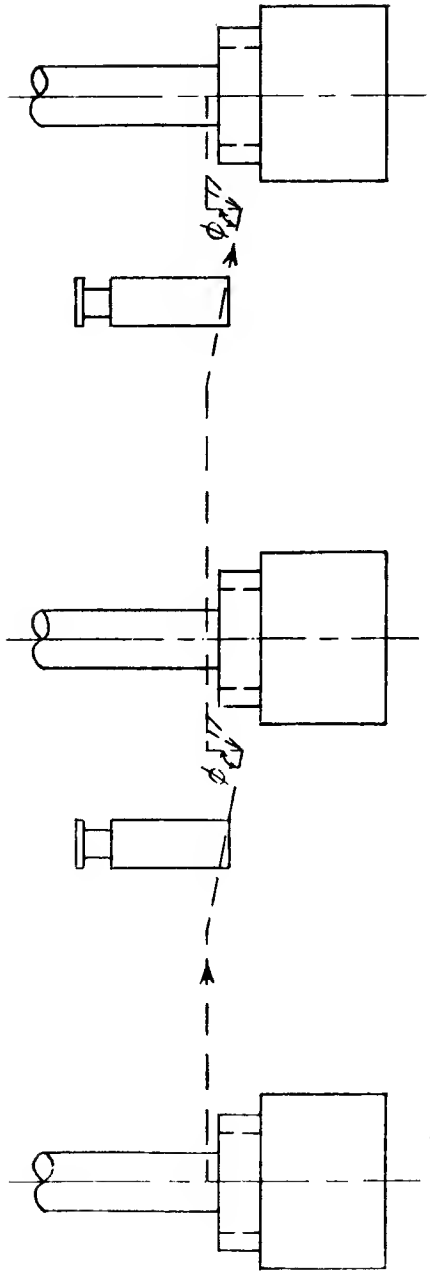
SPECIAL NOTES

1. USE 27180 LOCTITE. APPLY TO ENTIRE LENGTH OF THREAD.

MOTOR DATA

PNEUMATIC ROTARY SIX VANE TYPE DESIGNED FOR OPERATION ON 90 TO 120 POUNDS AIR PRESSURE.


ANVIL
JAW PIN
CLOCKWISE ROTATION


COUNTERCLOCKWISE ROTATION

ENGINEERING CASE LIBRARY

ECL 93B

Design of a Compact Air Driven Impact Wrench at Skil Corporation (B)

By July 7, 1962, the first layout assemblies of the "Imp" were off the board, (Exhibit B-1 and Exhibit B-2), and headed for the model shop where the first prototype was to be made (Exhibit B-3). By October 1 the first model was finished.

The impression of all was "I think we have something here, but will it work?" So off to testing it went.

But how do we test it? We can check it dynamically, for functional operations; bash it around for durability or any one of a dozen more tests, "but is this enough?" thought Pete. "Too, we can field test it, but if we do this and something goes wrong, then we have to pull it back in. And that isn't good." These were the questions going through Pete's mind as he headed for the Conference Room and the "Monday morning quarterback session" of the Engineering Department.

As the Meeting progressed, Pete still wasn't satisfied as to an answer. But then, decision time was here.

"How's the Imp coming, Pete?" Frank Kaman, his boss, asked. "Any conclusive tests yet?"

"Not completely," Pete replied. "I'm not satisfied that we're ready for fielding yet." And Pete proceeded to elaborate to the group his problem. "It works, it looks good, it feels good, I think it's the answer, but yet something's not quite right.

I wonder if the trade will accept it; we don't want a 'dud'. I think we need a controlled field test. But how?"

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"Easy," replied Frank, "this thing all started over a car, so let's go back to one to get the answer. Let's get an old one in here in the lab and start taking it apart and putting it together. This will give us absolute control. This is what it's designed for, let's see how it works. We'll 'debug' it ourselves and when we hit the market, we'll know it's a Skil, the best there is for the job."

This then was the "research lab" for the Imp. A 1955 "Super Duper"[1] complete with all the trimmings, power steering, power brakes, air-conditioning - the "works", was purchased.

Emory Hall, a young engineer with the company had come to Skil five years ago directly from engineering college in the Chicago area with a Bachelors degree in Mechanical Engineering. Emory had taken advantage of the company supported plan of continuing education, and was only a course or two from completing his requirements for a Masters degree in Mechanical Engineering, specializing in design.

Pete had called Emory into his office and told him, "Emory, I'm putting you in charge of testing the "Imp". Give'er hell! We want to know, right or wrong, what she'll do."

Emory's first reaction was, "What did I do this time? This isn't design." But as he thought over Pete's comment, "If there is anything missing, make it work...", he wasn't so sure.

That afternoon as he looked under the hood of the "Super Duper", he realized that Pete's "make it work" covered a lot of territory. His first observation was that although the size capacity of the "Imp" for bolts and nuts was 3/8" nominal diameter, it comprised about 95% of the fastener sizes. There were a few bolts and nuts on the car that the "Imp" could not handle, but most of these were readily assembled with their larger wrenches.

---

[1] Fictitious

With an auto mechanic especially hired for the test and a technician assisting, he proceeded to dismantle the "Super Duper". To guide him in his analysis of the "Imp", he used the Flat Rate Procedure Manual, common to all repair shops.

His reasoning was, if a mechanic uses this, then I will have a comparative check:

(1) Will the wrench work in a prescribed disassembly sequence?

(2) If it does, can it save time over a "trade" accepted standard? With this in mind, Emory proceeded with the analysis.

Emory prescribed the job and sequence of disassembly, noting any difficulty that arose, while the mechanic proceeded with the work. The "Imp" was working satisfactorily as expected, with one exception. Too many fasteners had to be bypassed because of inaccessibility. Here, Emory decided, was what Pete meant when he said, "Mke it work".

Emory recognized the need for an attachment to reach these bolts and nuts that are blind or are covered by some overhanging part. "Our mechanic, I recall, could not remove the fan with the 'Imp', even using our standard attachments. If we had an attachment that was offset about six inches - reasonably thin - could be rotated at ninety degrees to the drive axis but still locked about every fifteen degrees - and the drive end use our standard sockets - I think we'd be in business!"

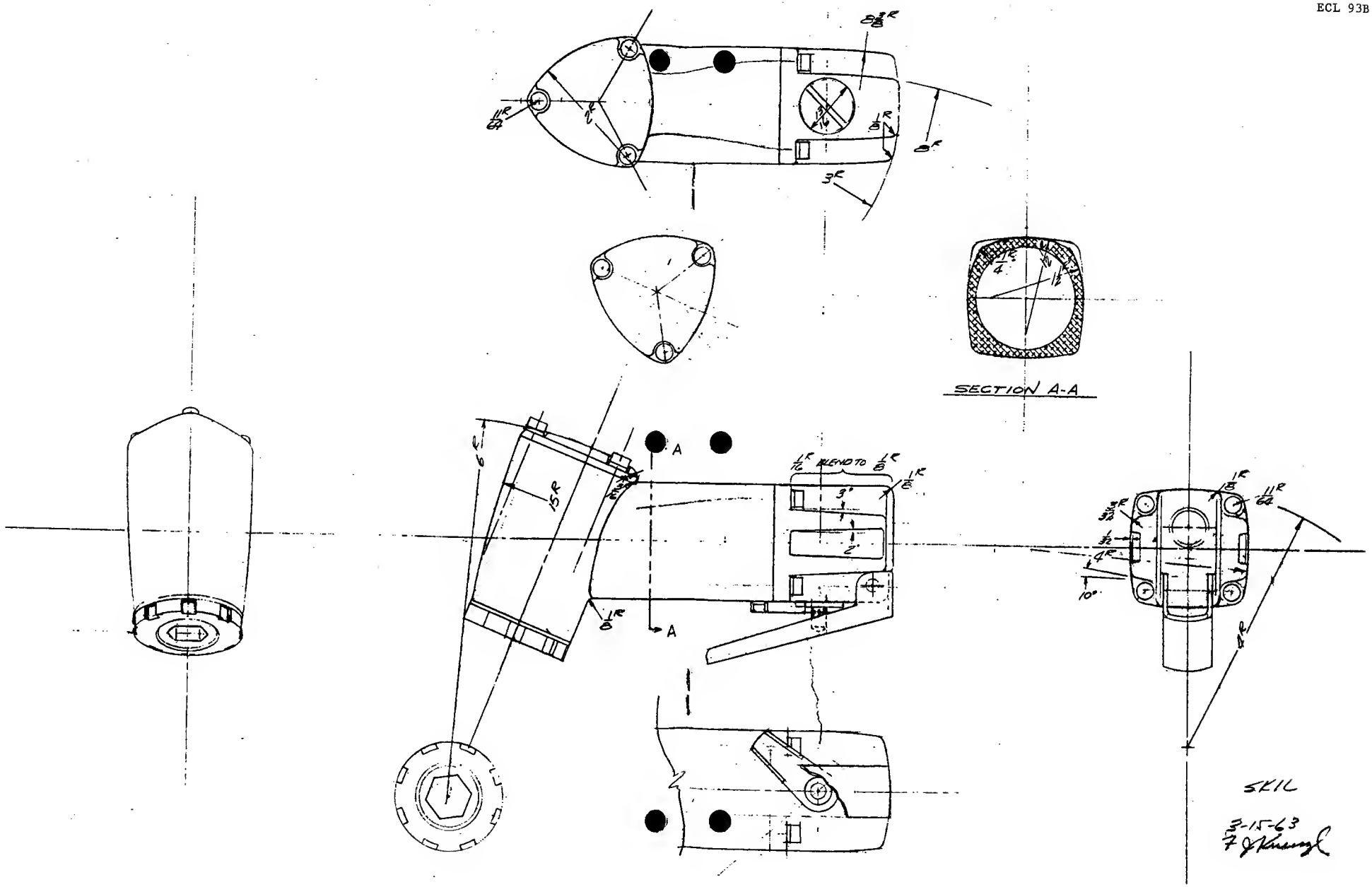
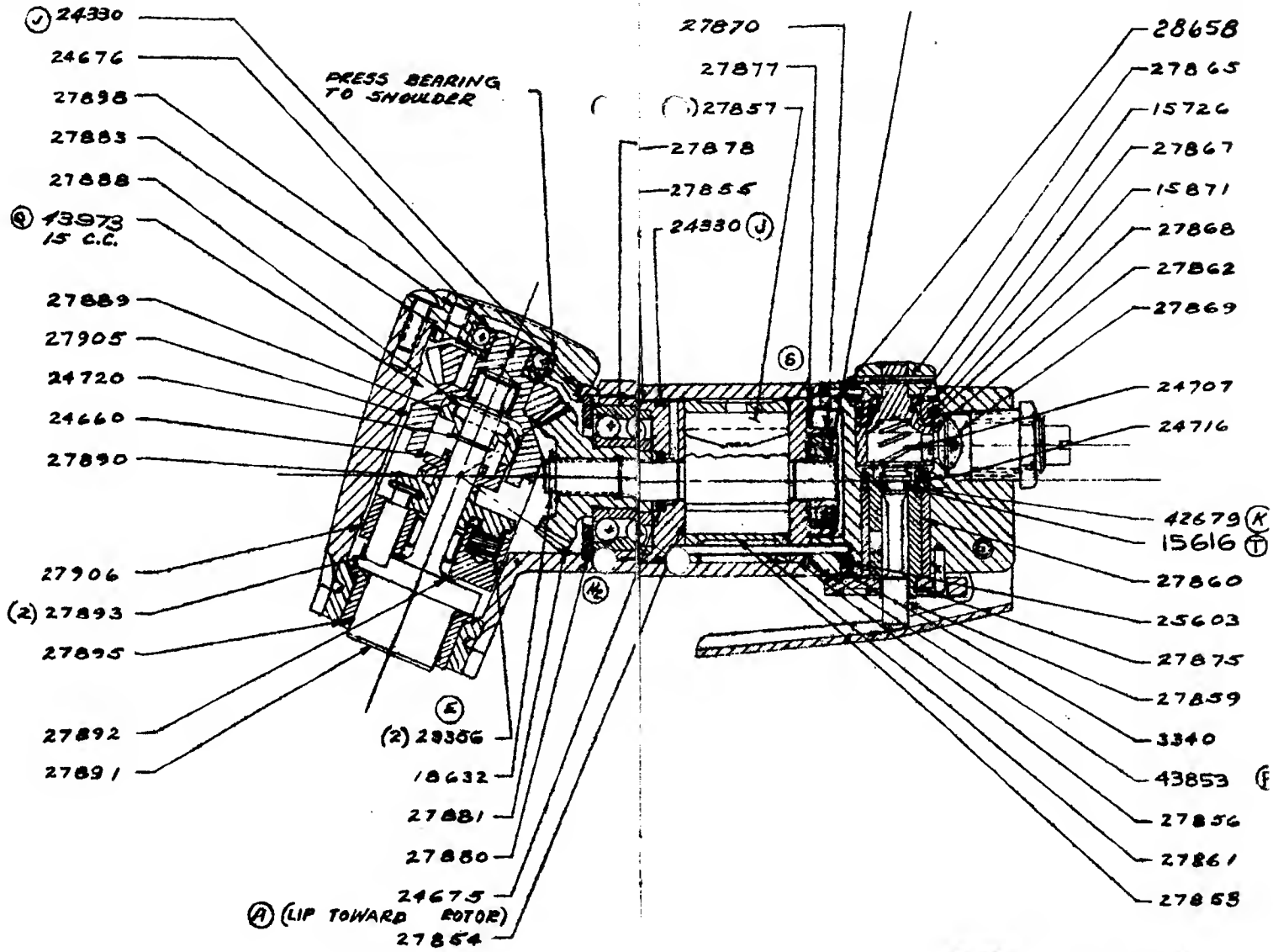


Exhibit B-1



PART NO.	C- 1120 - T1
	SKIL CORPORATION CHICAGO, ILL.
PART NAME	ANGLE AUTOMOTIVE IMPACT WRENCH
MATERIAL	
SIZE	

Exhibit B-2

Design of a Compact Air Driven Impact Wrench

at

Skil Corporation (C)

Emory proceeded to the drawing board to elaborate on some of his ideas. A few of his ideas are shown in Exhibits C-1 through C-4.

Exhibit C-1 is one of Emory's first ideas. This design allowed the toothed socket (on left hand end of drawing) to be changed and enabled the flat attachment to accommodate a larger number of fastener sizes. A bolt could be tightened or loosened by reversing the direction of rotation of the air wrench.

Exhibit C-2 shows one design change. The spring detent which prevents free rotation of the toothed socket was changed from a flat spring in C-1 to a coil spring type.

After two months, the flat attachment was redesigned and the result is shown in Exhibit C-3. Here a bolt can be tightened or loosened by moving the switch on the cover of the attachment. This causes a different pawl to engage the toothed socket and thus reverses the rotation because the pawls engage the socket on opposite sides. The interposer between the pawls also serves as a detent mechanism.

The attachment in Exhibit C-4 is very similar to the one in Exhibit C-3; however, it incorporates a couple of modifications. The switch which reverses the rotation now has a detent to lock it into position and the shape of the interposer has been changed. With these alterations Emory felt that he had a workable attachment. However, after testing Emory came up with a better solution.

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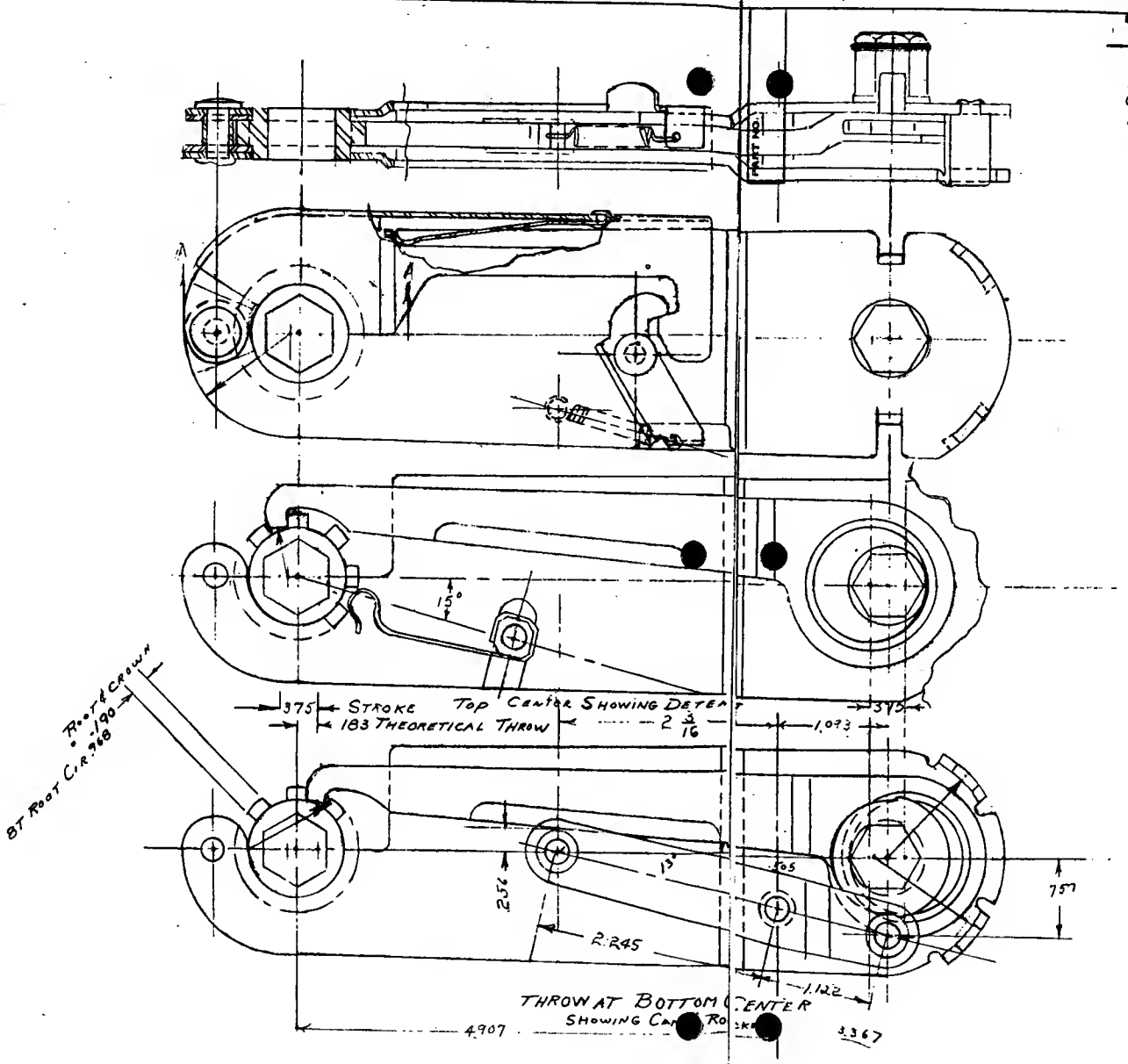
The redesigned mechanism is shown in Exhibits C-5 and C-6. This is the design that was put into production. It uses an eccentric operated pawl and a ratchet socket which has its detent mechanism pinned to the frame. The direction of socket rotation can be reversed by turning the flat attachment over.

Exhibit C-7 pictures the flat attachment in use and gives the operating instructions.



DISTRIBUTION CODE 4 3 2 1 0

* TEETH - 8
ROOT TEETH .9675
OD SOCKET 1.280
HEX ACROSS COR .722
WIDTH ROOT & TOOTH .190

PART NO. D-226-300-18

SKIL CORPORATION CHICAGO, ILL.

PART NAME — EXPERIMENTAL REV. RATCHET

MATERIAL —

SIZE —

LBS. PER 1000 PCS. —

FEET PER 1000 PCS. —

HEAT TREAT.

ROCKWELL "J" 48 TO 1963

FINISH

SCALE	DRN. BY	CKD. BY	APP. BY
1X	6214		

P.S.

USED ON

P.E.O.

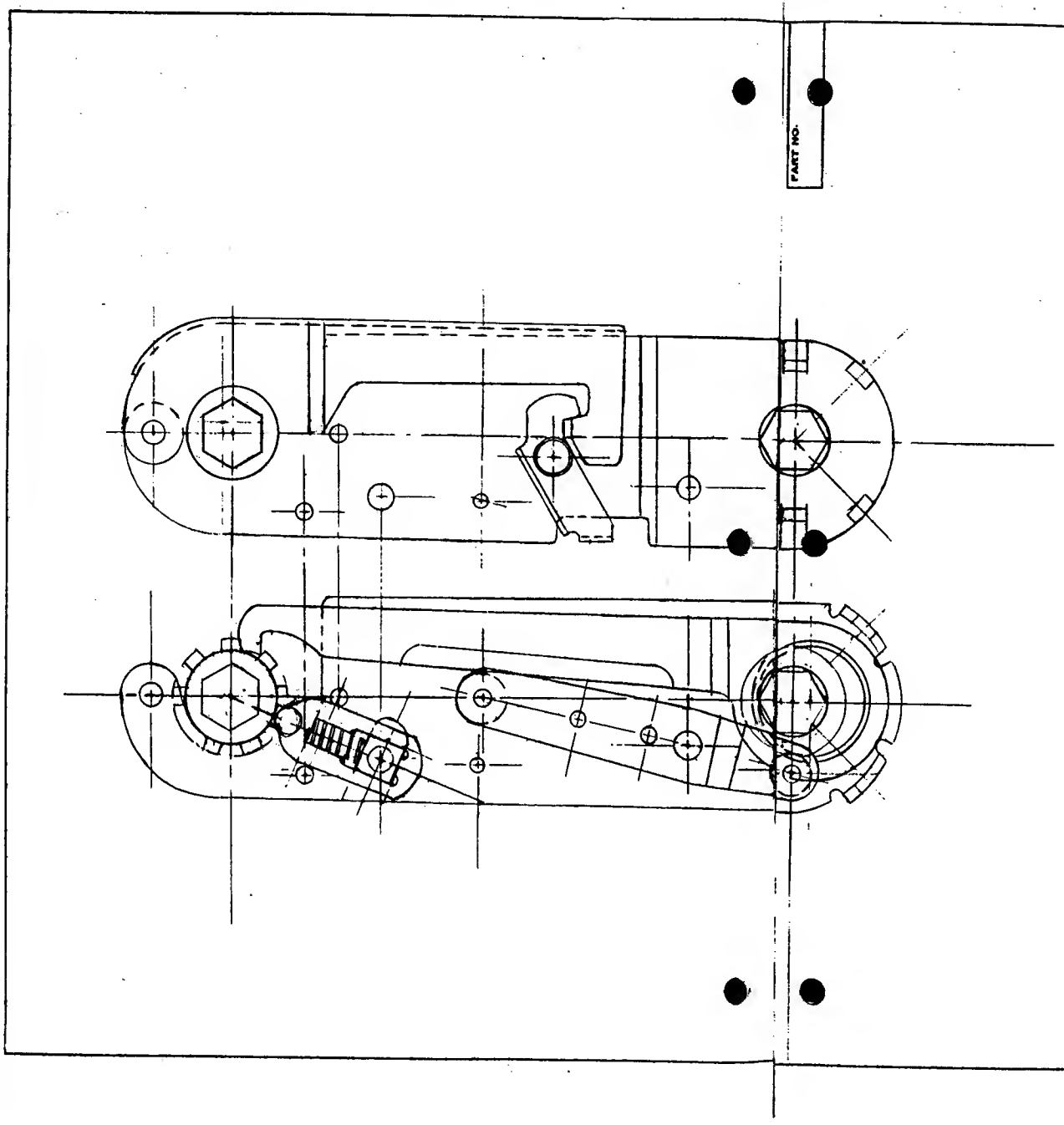
REVISIONS	LOG.
A	

DESTROY PREVIOUS PRINTS

JUL 10 1967

LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIM. ±
DECIMAL DIM. ±.
ANGULAR DIM. ±
CONCENTRICITY BETWEEN ▽ AND ▽ T.I.R.
REMOVE ALL BURRS

Exhibit C-1



DISTRIBUTION CODE 4 3 2 1 0

PART NO.

SKIL CORPORATION
CHICAGO, ILL.

PART NAME —

MATERIAL —

SIZE —

LBS. PER 1000 PCS. —
FEET PER 1000 PCS. —

HEAT TREAT.

ROCKWELL " " TO

FINISH

SCALE	DRN. BY	CKD. BY	APP. BY
F.S.			

USED ON

P.E.O.

REVISIONS | LOC.

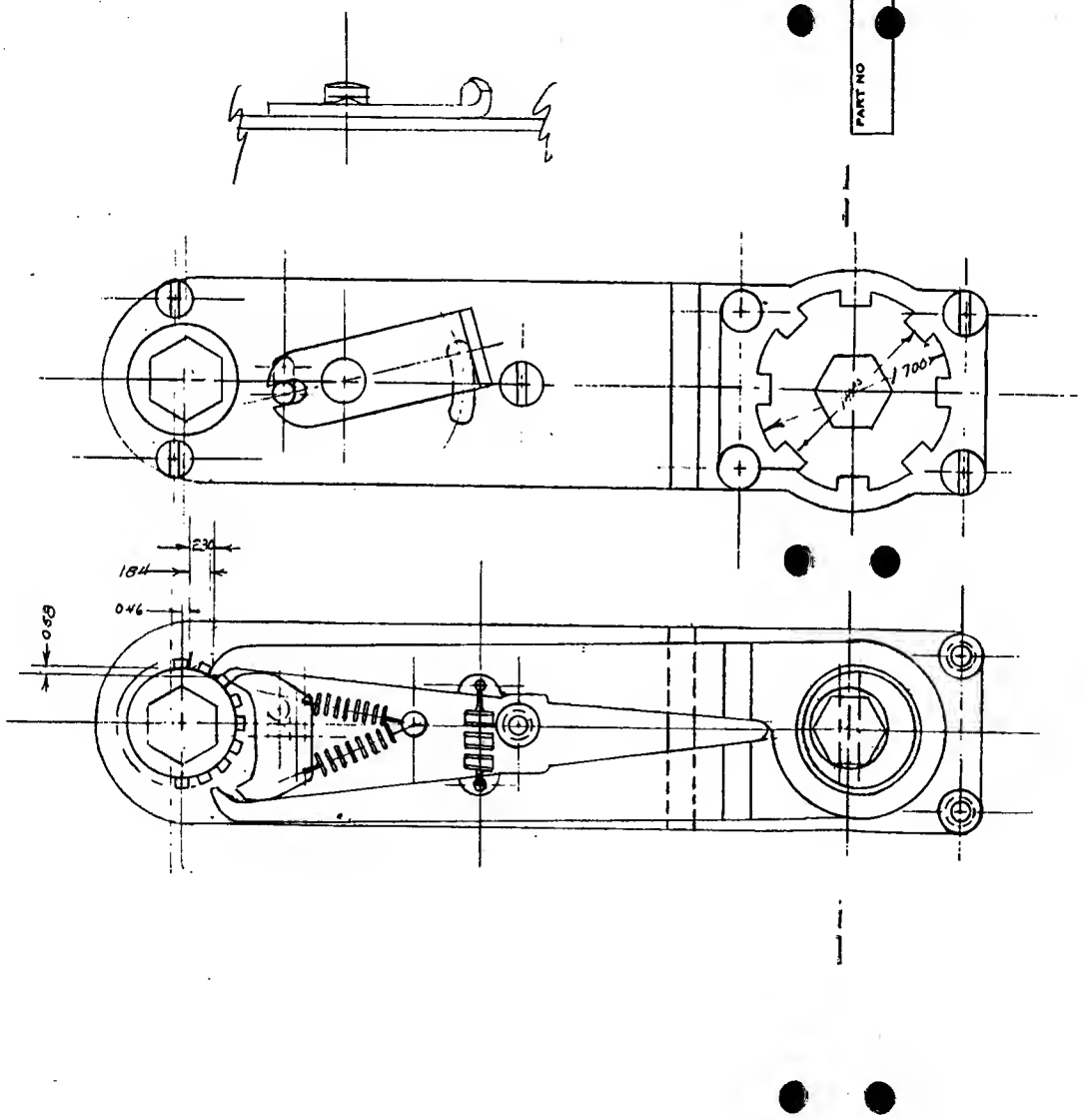
A

DESTROY PREVIOUS PRINTS

JUL 1 0 1967

LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIM. ±.
DECIMAL DIM. ±.
ANGULAR DIM. ±.
CONCENTRICITY BETWEEN
AND T.I.R.
REMOVE ALL BURRS

Exhibit C-2



DISTRIBUTION CODE 5 4 3 2 1 0

PART NO.

SKIL CORPORATION
CHICAGO, ILL.

PART NAME— IMPACT FLAT ATTACH

MATERIAL—

SIZE—

LBS. PER 1000 PCS.—

FEET PER 1000 PCS.—

HEAT TREAT.

ROCKWELL " " TO

FINISH

SCALE	DRN: BY	CKD. BY	APP. BY
1X	E.H.		
P.E.	Sept 1		

USED ON

P.E.O.

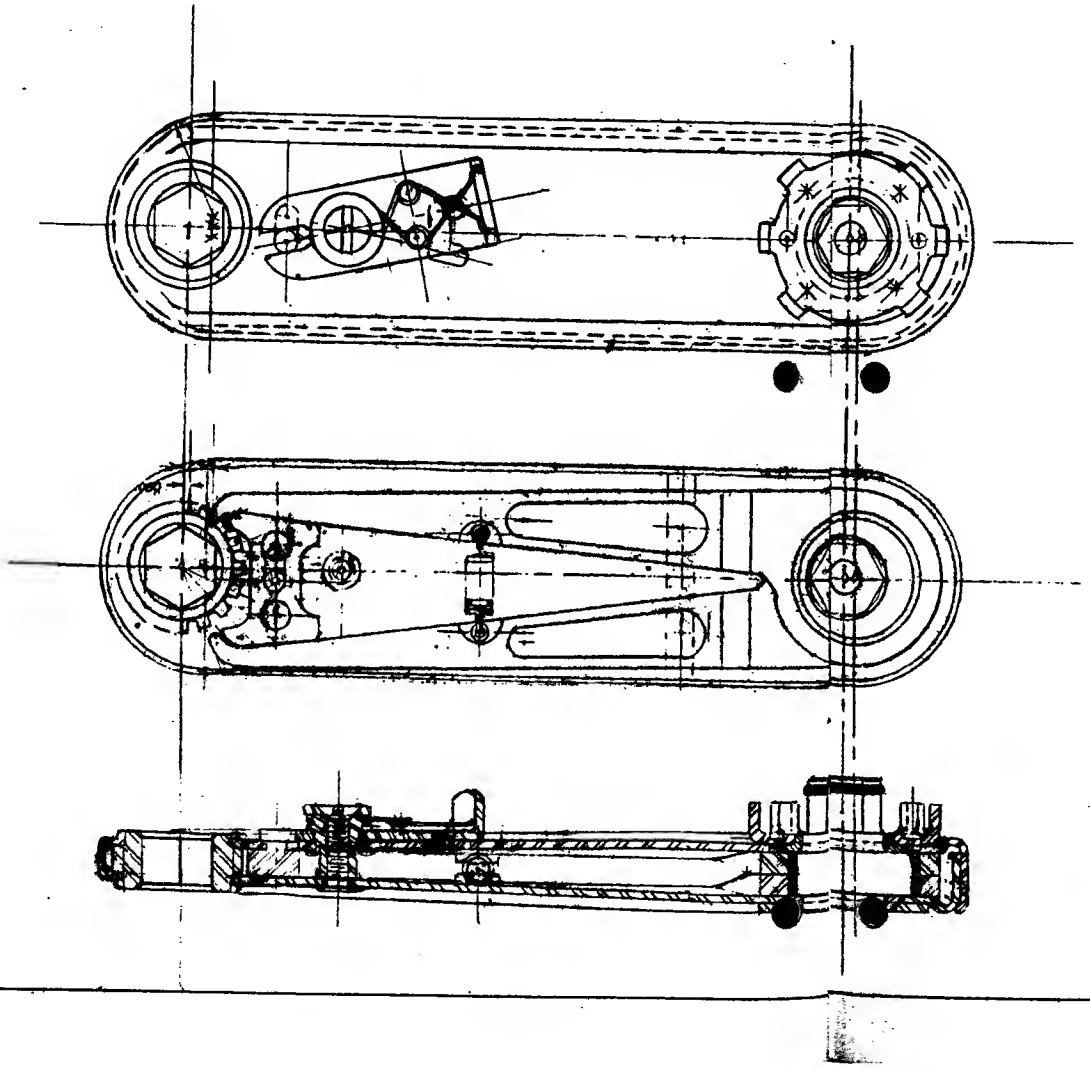
REVISIONS LOG

A

DESTROY PREVIOUS PRINTS

JUL 10 1967

LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIM. ±
DECIMAL DIM. ±.
ANGULAR DIM. ±
CONCENTRICITY BETWEEN
AND
T.I.R.
REMOVE ALL BURRS



DISTRIBUTION CODE 5 4 3 2 1 0

PART NO.

SKIL CORPORATION
CHICAGO, ILL.

PART NAME — DROP FLAT ATTACH ASSY

MATERIAL —

SIZE —

LBS. PER 1000 PCS. —
FEET PER 1000 PCS. —

HEAT TREAT.
✓
ROCKWELL " " TO

FINISH

SCALE	DRN. BY	CKD. BY	APP. BY
1X - P.S.	E.F.H.	12-2-63	

USED ON

P.E.O.

REVISIONS	LOC.
A	

DESTROY PREVIOUS PRINTS

JUL 10 1967

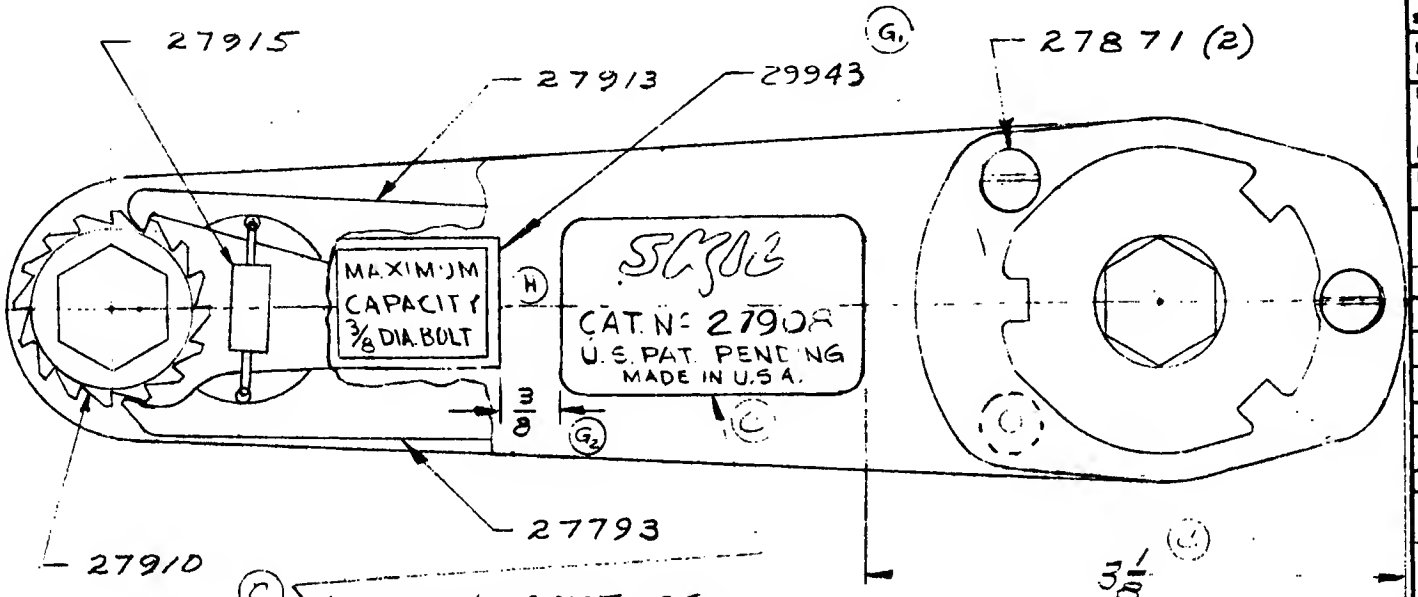
LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIM. ±
DECIMAL DIM. ±.
ANGULAR DIM. ±
CONCENTRICITY BETWEEN ▽ AND ▽ T.I.R.

REMOVE ALL BURRS

Exhibit C-4

27908

NOTE:
STAKE THREAD END
OF ALL SCREWS



C 28111 - LOCATE AS SHOWN - ACTNATE WITH TRICHLORETHYLENE

3 1/8

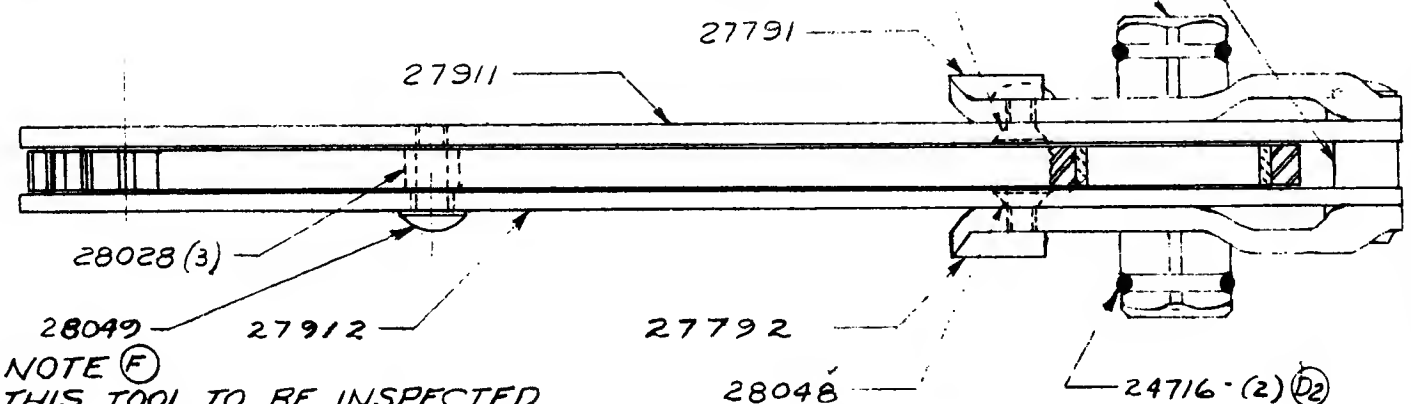
28026

27909 D1

DESTROY PREVIOUS PRINTS

SEP 9 1966

E LUBRICATION NOTE:
COAT BOTH SIDES OF THE THRUST (27793) AND STOP PAWL (27913) AND INSIDE OF BEARINGS WITH SKIL SPEC 30101 LUBRICANT.



NOTE F
THIS TOOL TO BE INSPECTED TO 4b112

SKIL CORPORATION
CHICAGO, ILL.

PART NAME — FLAT ATTACHMENT FOR IMPACT WRENCH

MATERIAL — AS NOTED

SIZE —

LBS. PER 1000 PCS. —
FEET PER 1000 PCS. —

HEAT TREAT.
ROCKWELL " " TO

FINISH

SCALE	DRN. BY	CKD. BY	APP. BY
1:1	W.L.G.	L.N	EFF
C-4	12-2-63	12-16-63	12-16-63

217-236 MODEL Nos.

1121-T1				

REVISIONS

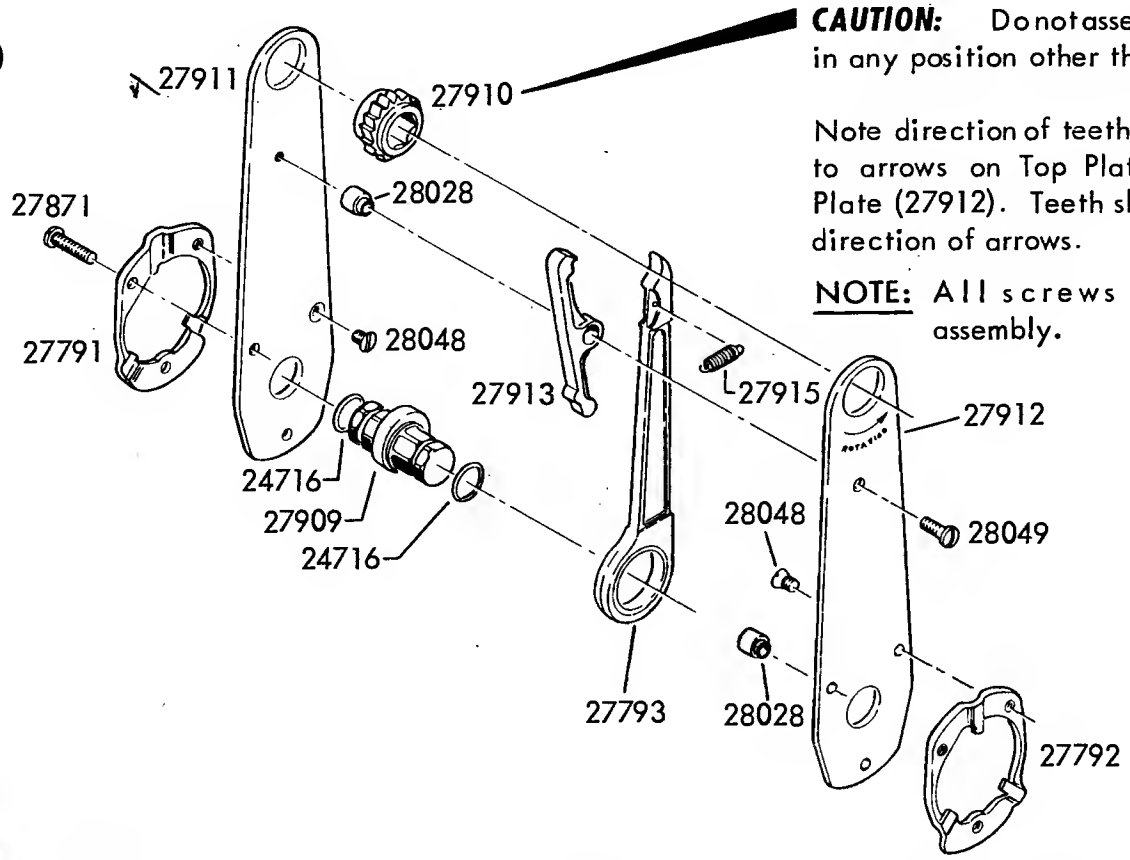
A	EC# 6859 1-17-64 W&G. REDESIGNED
B	EC# 6937 2-6-64 C.G. WAS 27916 (2)
C	EC 6971 2-26-64 [illegible] ADD: 28171 NAMEPLATE 3/8" DIM & NOTE
D1	EC# 7007 3-16-64 WLG
D2	27909 WAS 27794 ADDED 24716 (2)
E	EC 7244 6-12-64 RL ADD LUBRICATION NOTE
F	EC 7369 7-14-64 R.L. ADD INSPECTION NOTE
G1	EC 7815 2-22-65 R.J.A ADD. #29943
G2	ADD 3/8 DIM
H	EC 9391 9-1-66 J.M. STICKERS 28171 & 29743 ROTATED 180°

LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIM. ±
DECIMAL DIM. ±.
ANGULAR DIM. ±
CONCENTRICITY BETWEEN ▽ AND ▽ T.I.R.
REMOVE ALL BURRS

Exhibit C-5

ECL 93C

SKIL NO. 27908 FLAT ATTACHMENT



CAUTION: Do not assemble RATCHET (27910) in any position other than illustrated.

Note direction of teeth on Ratchet in relation to arrows on Top Plate (27911) and Bottom Plate (27912). Teeth should point in opposite direction of arrows.

NOTE: All screws must be staked after assembly.

PART NO.	PART NAME	NO. USED
24716	"O" Ring	2
27791	Top Plate Adapter	1
27792	Bottom Plate Adapter	1
27793	Pawl & Bearing Assembly	1
27871	Screw	2
27909	Eccentric Shaft	1
27910	Ratchet	1
27911	Top Plate	1
27912	Bottom Plate	1
27913	Stop Pawl	1
27915	Tension Spring	1
28028	Pivot Spacer	3
28048	Screw	2
28049	Screw	1

SKIL POWER TOOLS

INSTRUCTION SHEET
for NO.27908
FLAT ATTACHMENT
USED WITH SKIL MODEL 1120 AIR IMP WRENCH

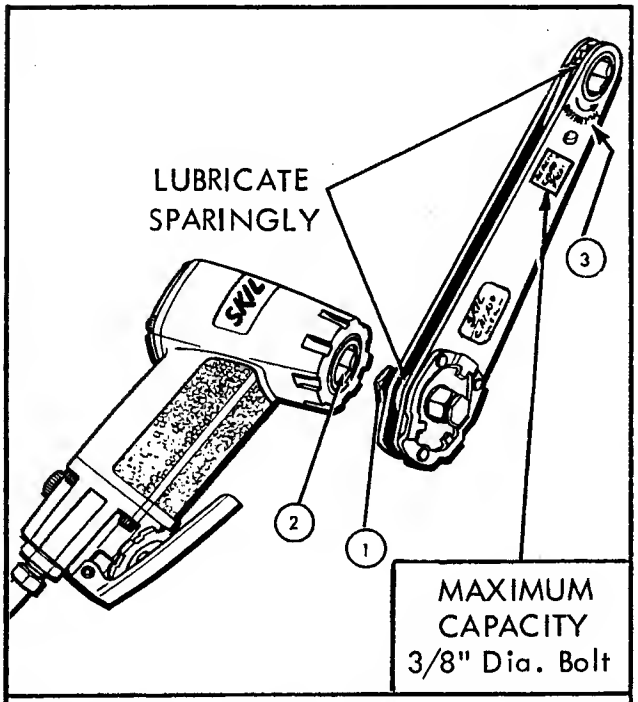


Fig. 1 ATTACHING FLAT ATTACHMENT TO MODEL 1120 AIR IMP WRENCH

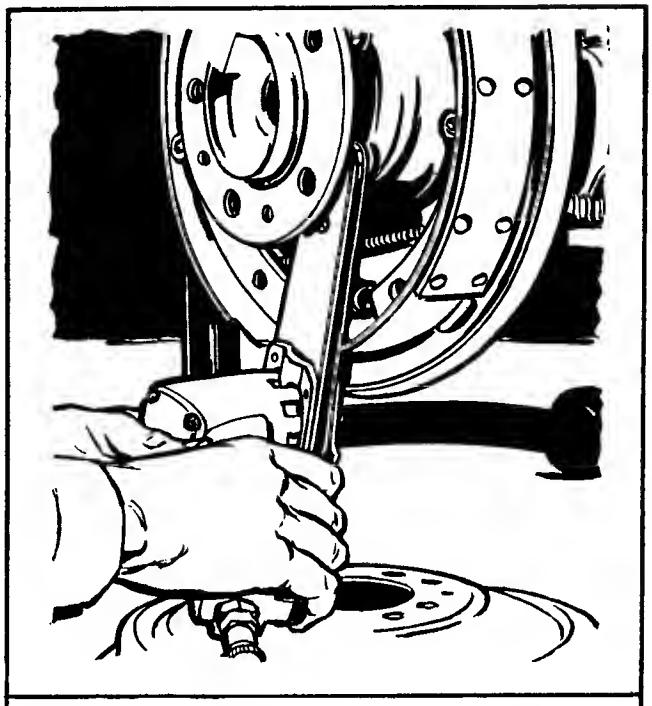


Fig. 2 REMOVING REAR AXLE

OPERATING INSTRUCTIONS

Simply insert the hex shaft of the FLAT ATTACHMENT (fig. 1, item 1) into the recessed 5/8" hex drive socket of the AIR IMP WRENCH (fig. 1, item 2). For operation in the opposite direction, turn the FLAT ATTACHMENT over and use the same procedure. An arrow shows the direction of rotation (fig. 1, item 3). This attachment can be used from any angle (see fig. 2).

When using the FLAT ATTACHMENT in close quarters, keep a firm grip on the IMP WRENCH. When a nut or bolt has been run down and begins to tighten, or when a tight nut or bolt is loosened, the attachment and wrench will tend to rotate if they are not held in place.

CAUTION: Care should be taken not to let dirt and other foreign matter accumulate in the ratchet area.

This attachment should NOT be used.....

1. On jobs requiring more than 50 ft. lb. of torque.
2. On a nut or bolt continuously for more than 2 to 3 seconds.

MAINTENANCE INSTRUCTIONS

Be sure that the recessed 5/8" hex drive socket is cleaned of all foreign matter before inserting the FLAT ATTACHMENT.

A periodic inspection will reduce maintenance cost, and proper lubrication will keep your FLAT ATTACHMENT in first class condition.

Place lubricant (SKIL No. 252, 5 oz. tube) lightly around the ratchet area and the hex shaft (see fig. 1).

(See other side for Diagram & Parts List.)

ECL 93D

Design of a Compact Air Driven Impact Wrench at Skil Corporation (D)

The flat, off-set attachment that is used with Skil's model 1120 air impact wrench is shown in Exhibits D-1 and D-2. The part is readily attachable to the wrench and uses the same sockets used by the wrench. Refer to previous parts of ECL 93 for an account of the development of the wrench and attachment.

This case was prepared by Mr. Robert Martin under the direction of Professor Henry O. Fuchs with support from the National Science Foundation through the Case Program of the Design Division, Mechanical Engineering Department. Grateful acknowledgment is given to the Skil Corporation, Professors Richard Thompson of Purdue University and Robert Wickham of Ohio University for their cooperation.

The attachment is a ratchet mechanism. The eccentric portion of the shaft (#27909) fits into the bearing in the pawl and bearing assembly (#27793) and as the shaft rotates the eccentric causes the pawl to oscillate. The pawl is held against the ratchet (#27910) by a spring (#27915). Thus, as the pawl oscillates it alternately engages and slips over the ratchet teeth. As viewed in Exhibit D-1, the ratchet will rotate in the counter-clockwise direction. The ratchet teeth slip under the stop pawl (#27913) while the pawl is engaged. The stop pawl engages to prevent the ratchet from rotating as the pawl slips over the ratchet teeth. To reverse the direction of rotation the attachment is simply turned over; the eccentric shaft has a hex drive on each end.

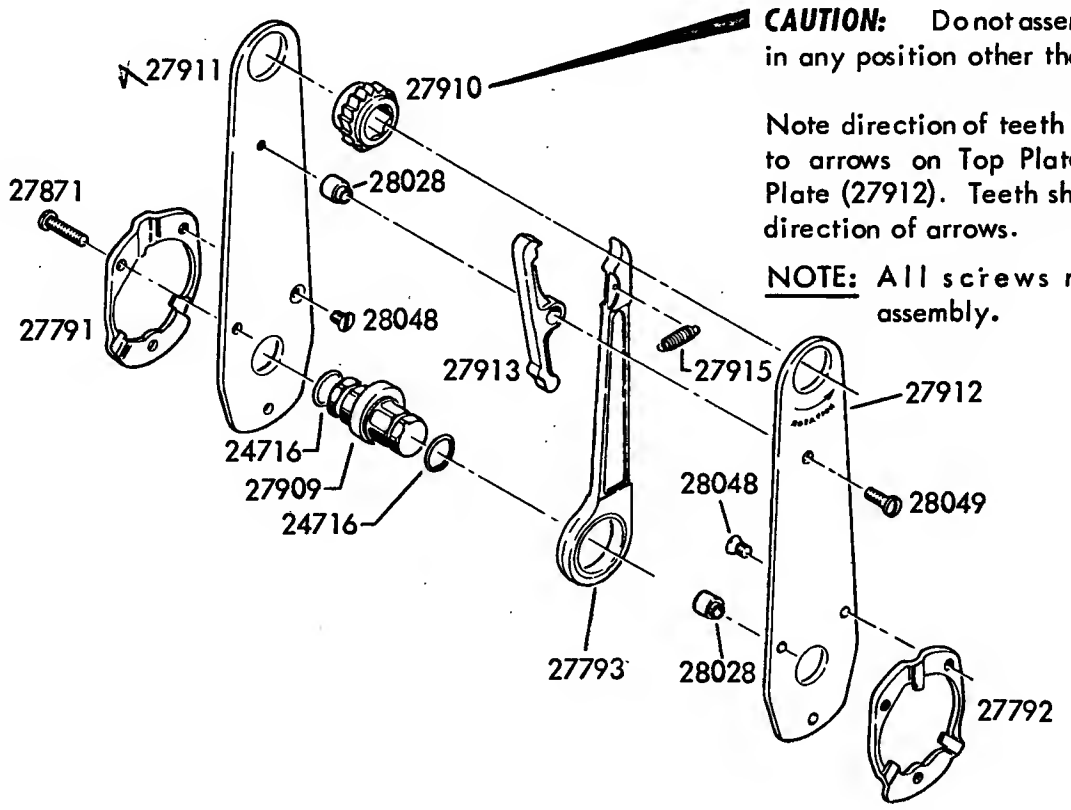
Detailed drawings, without notes and dimensions, of the attachment parts are shown in Exhibits D-3 through D-7.

The bottom and top plates (Exhibit D-3) are made from AISI C1075 cold-rolled, annealed, spring steel. The areas around the diameters of the large holes in both plates are bearing surfaces that support the loads on the ratchet and eccentric shaft while the attachment is in operation. Therefore the metal within 3/16 inch of the diameters of these holes is induction hardened and tempered to a hardness of Rockwell C 53 to 55.

Both the pawl (Exhibit D-4) and the stop pawl (Exhibit D-5) are made of AISI E4340 cold-finished, aircraft quality steel. A vendor produces the forging and anneals it to a maximum hardness of Rockwell C 30. The parts are machined; then they are carburized 0.010 to 0.012 inch deep, and hardened and tempered to a hardness of Rockwell 15N 89 to 90. This corresponds to a Rockwell C hardness of 53 to 54.

The material used to make the eccentric shaft (Exhibit D-6) and the ratchet (Exhibit D-7) is AISI E 4340 cold-finished, aircraft-quality steel. The ratchet is carburized to a depth of 0.010 to 0.012 inch, then hardened and tempered to a hardness of Rpckwell 15N 86.5 to 87.5. This corresponds to a Rockwell C hardness of 51 to 52. The eccentric shaft is hardened and tempered to a hardness of Rockwell C47 to 50.

SKIL NO. 27908 FLAT ATTACHMENT



CAUTION: Do not assemble RATCHET (27910) in any position other than illustrated.

Note direction of teeth on Ratchet in relation to arrows on Top Plate (27911) and Bottom Plate (27912). Teeth should point in opposite direction of arrows.

NOTE: All screws must be staked after assembly.

PART NO.	PART NAME	NO. USED
24716	"O" Ring	2
27791	Top Plate Adapter	1
27792	Bottom Plate Adapter	1
27793	Pawl & Bearing Assembly	1
27871	Screw	2
27909	Eccentric Shaft	1
27910	Ratchet	1
27911	Top Plate	1
27912	Bottom Plate	1
27913	Stop Pawl	1
27915	Tension Spring	1
28028	Pivot Spacer	3
28048	Screw	2
28049	Screw	1

MANUFACTURERS OF FAMOUS SKIL AND SKILSAW PRODUCTS

SKIL POWER TOOLS

INSTRUCTION SHEET

for NO.27908

FLAT ATTACHMENT

USED WITH SKIL MODEL 1120 AIR IMP WRENCH

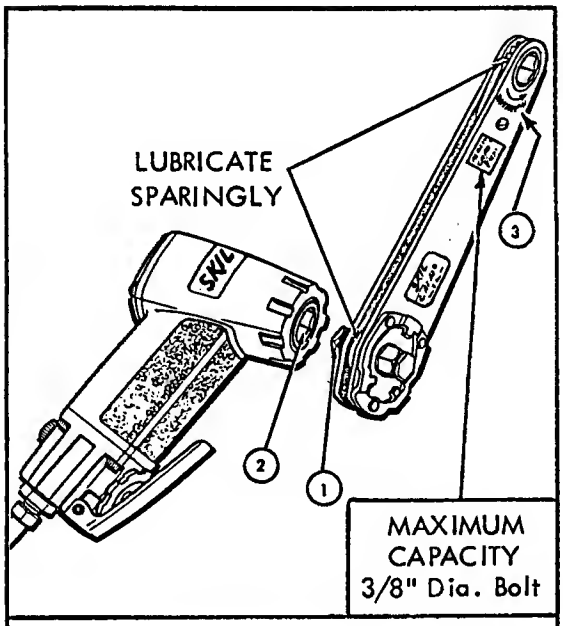


Fig. 1 ATTACHING FLAT ATTACHMENT TO MODEL 1120 AIR IMP WRENCH

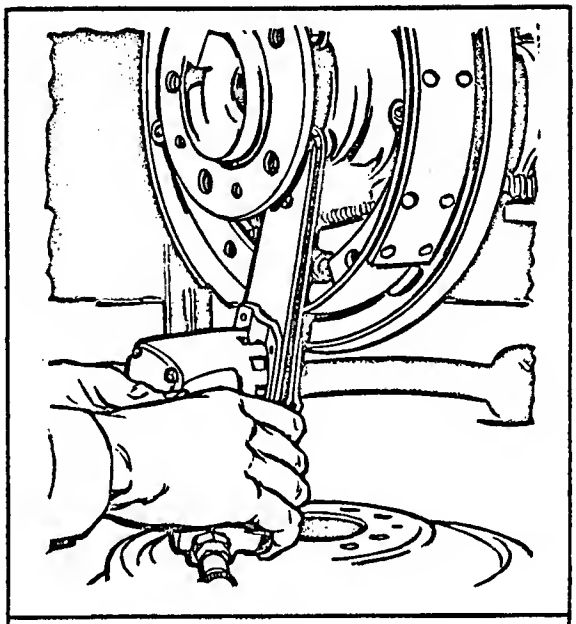


Fig. 2 REMOVING REAR AXLE

OPERATING INSTRUCTIONS

Simply insert the hex shaft of the FLAT ATTACHMENT (fig. 1, item 1) into the recessed 5/8" hex drive socket of the AIR IMP WRENCH (fig. 1, item 2). For operation in the opposite direction, turn the FLAT ATTACHMENT over and use the same procedure. An arrow shows the direction of rotation (fig. 1, item 3). This attachment can be used from any angle (see fig. 2).

When using the FLAT ATTACHMENT in close quarters, keep a firm grip on the IMP WRENCH. When a nut or bolt has been run down and begins to tighten, or when a tight nut or bolt is loosened, the attachment and wrench will tend to rotate if they are not held in place.

CAUTION: Care should be taken not to let dirt and other foreign matter accumulate in the ratchet area.

This attachment should NOT be used.....

1. On jobs requiring more than 50 ft. lb. of torque.
2. On a nut or bolt continuously for more than 2 to 3 seconds.

MAINTENANCE INSTRUCTIONS

Be sure that the recessed 5/8" hex drive socket is cleaned of all foreign matter before inserting the FLAT ATTACHMENT.

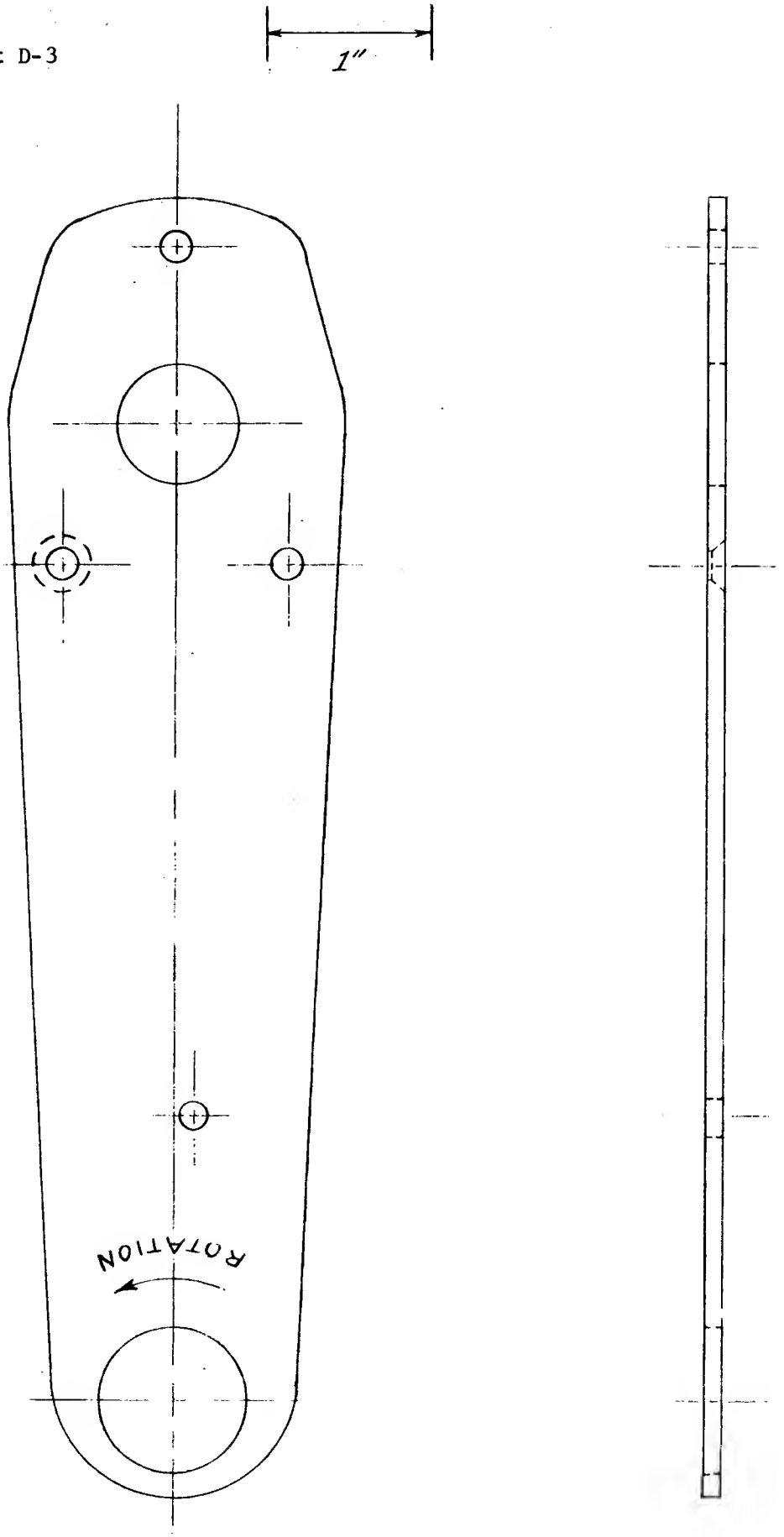
A periodic inspection will reduce maintenance cost, and proper lubrication will keep your FLAT ATTACHMENT in first class condition.

Place lubricant (SKIL No. 252, 5 oz. tube) lightly around the ratchet area and the hex shaft (see fig. 1).

(See other side for Diagram & Parts List.)

Exhibit D-3

ECL 93D

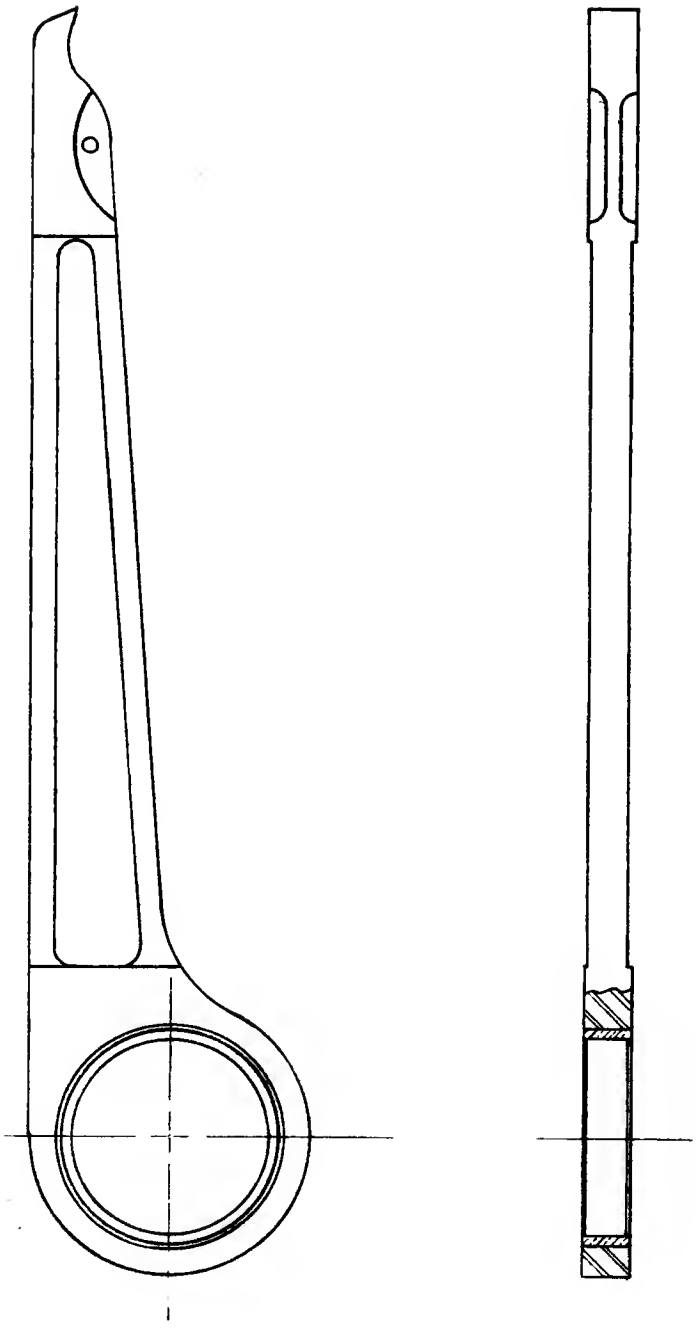


BOTTOM PLATE

Exhibit D-4

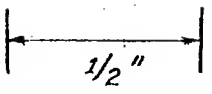
1"

ECL 93D

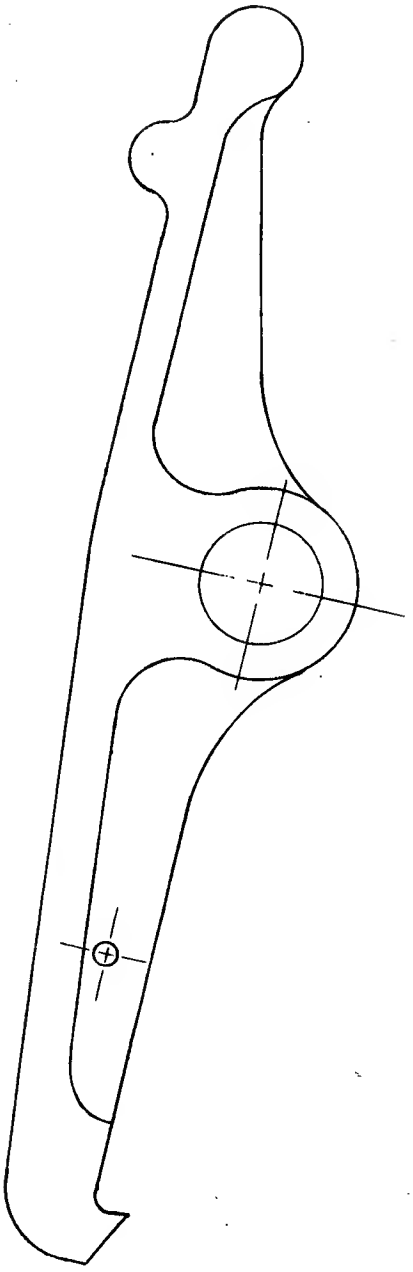


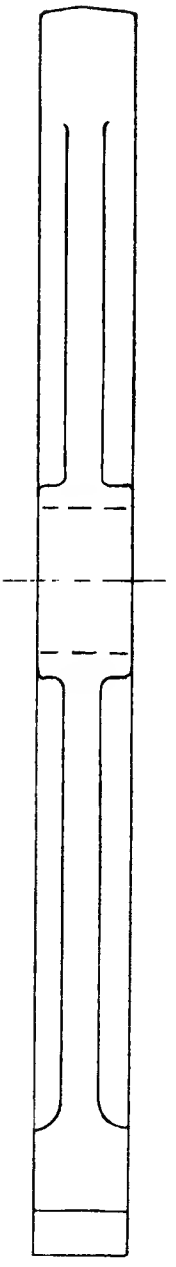
PAWL

Exhibit D-5

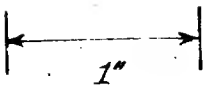


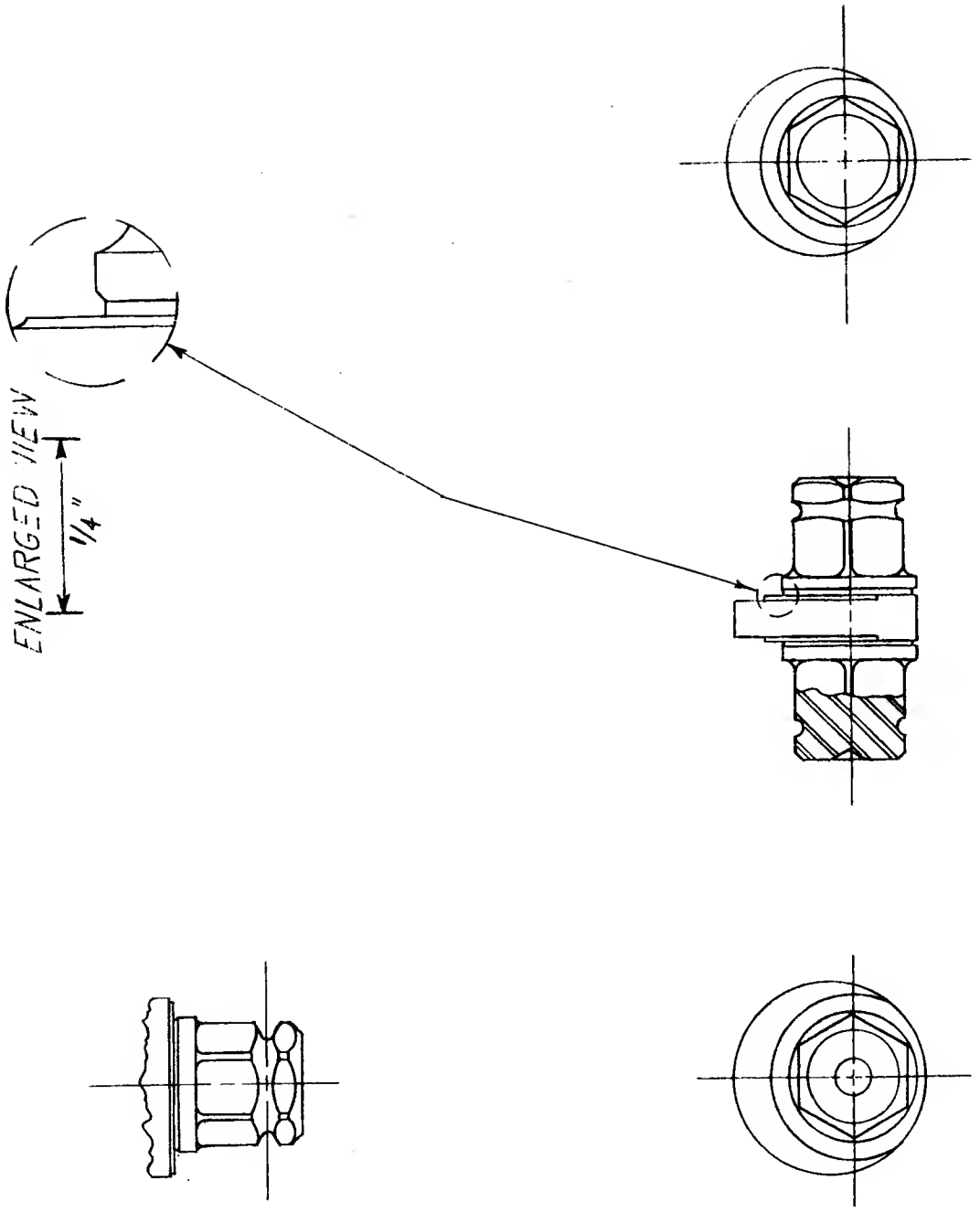
ECL 93D



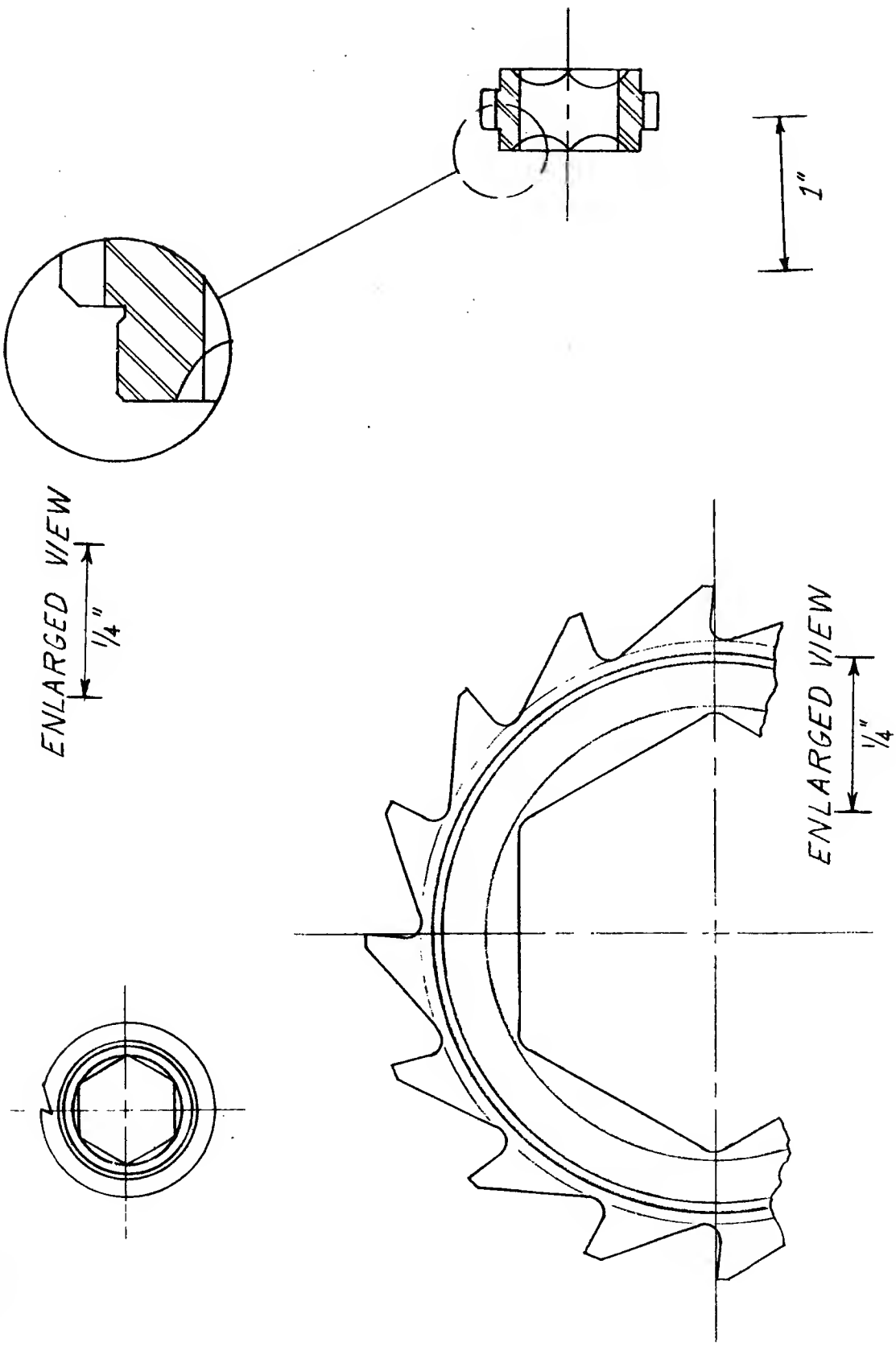


STOP PAWL





ECCENTRIC SHAFT


1"
ENLARGED VIEW
1/4"
ENLARGED VIEW
1/4"
RATCHET

Design of a Compact Air Driven Impact Wrench
at
Skil Corporation (E)

The detailed drawings, of part D are shown in this part with the notes and dimensions used at Skil Corporation (Exhibits E-1 through E-6).

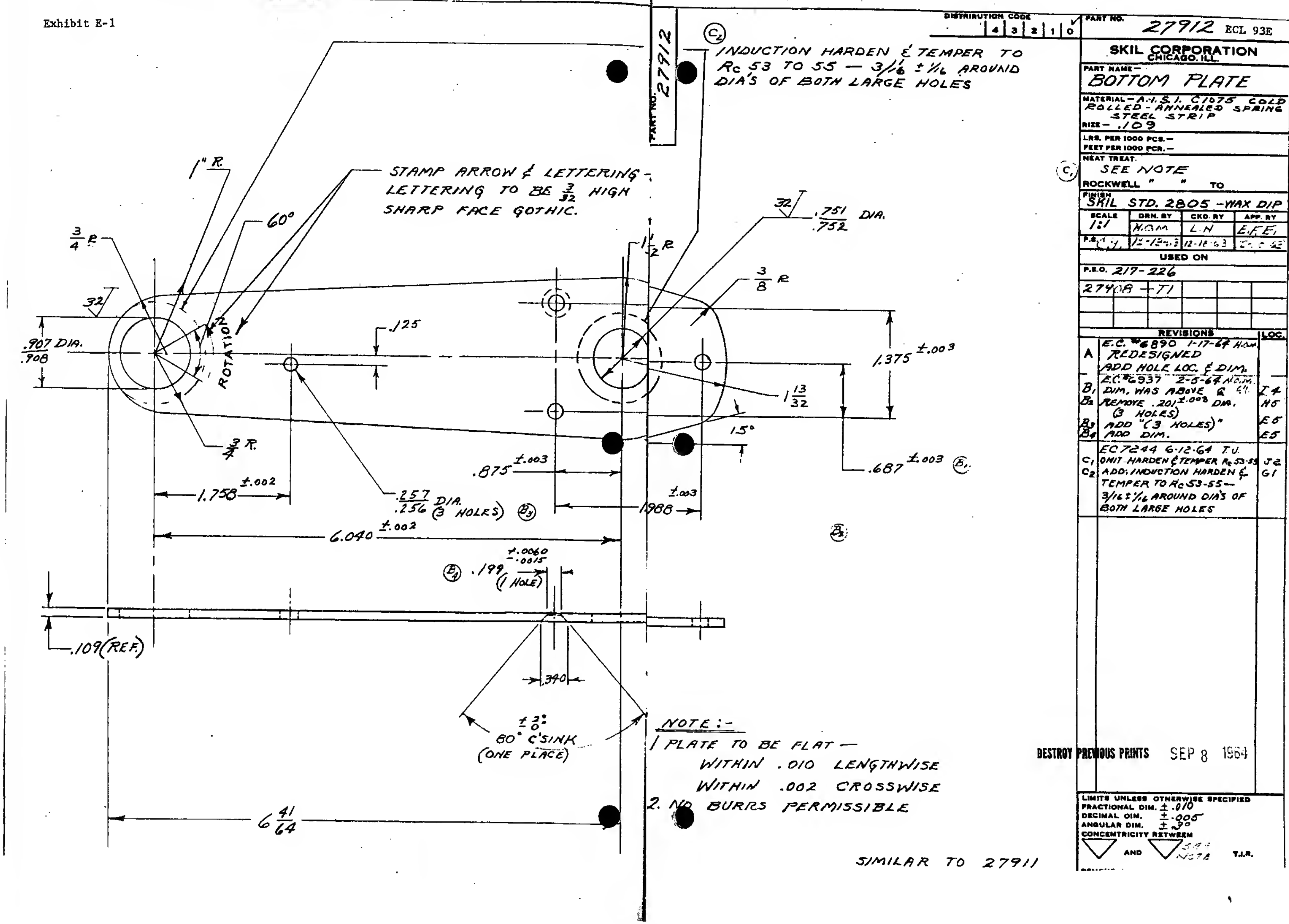
It is interesting to note that originally the bottom plate (Exhibit E-1) was hardened by carburizing to provide suitable bearing surfaces for the eccentric shaft and ratchet. In June of 1964, carburizing was discontinued and the areas around the two large holes were induction hardened instead. A reason for the change is that the plate is required to be flat within 0.010 inch lengthwise and 0.002 inch crosswise. The carburizing process required that the entire plate be heated to a high temperature, and quenched. This produced a tendency for the plate to warp. Induction hardening of small areas, greatly reduces the danger of warpage.

Exhibit E-2 and E-3 are drawings of the pawl. Exhibit E-2 is an assembly drawing and therefore contains no dimensions and manufacturing notes. It does show the manner in which the pawl and bearing are assembled. Exhibit E-3 contains the dimensions and notes necessary to manufacture the pawl.

Exhibits E-4 through E-6 are engineering drawings of the stop pawl, eccentric shaft, and the ratchet.

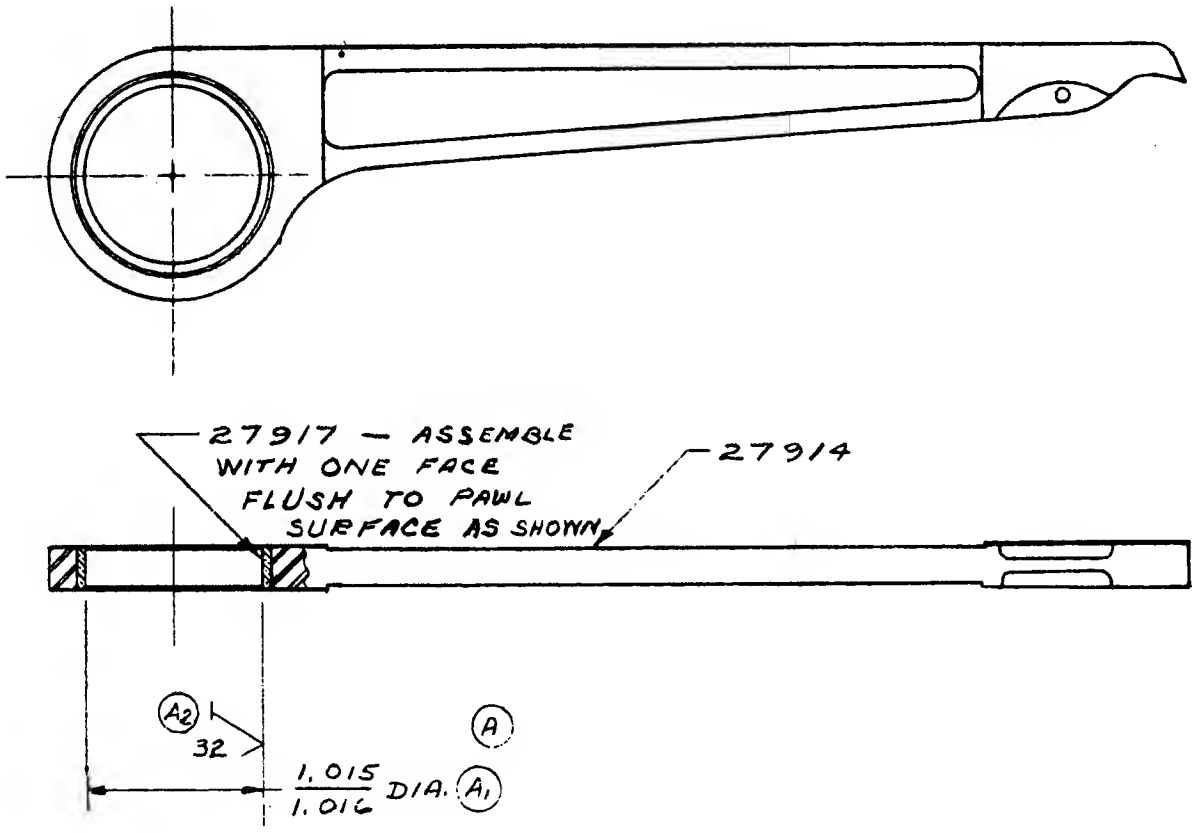
This case was prepared by Mr. Robert Martin under the direction of Professor Henry O. Fuchs with support from the National Science Foundation through the Case Program of the Design Division, Mechanical Engineering Department. Grateful acknowledgment is given to the Skil Corporation, Professors Richard Thompson of Purdue University and Robert Wickham of Ohio University for their cooperation.

Exhibit E-1



PART NO. 27912 ECL 93E
SKIL CORPORATION CHICAGO, ILL.
PART NAME – BOTTOM PLATE
MATERIAL – A.I.S.I. C1075 COLD ROLLED-ANNEALED SPRING STEEL STRIP
SIZE – .109
LBS. PER 1000 PCS. –
FEET PER 1000 PCS. –
HEAT TREAT. SEE NOTE
ROCKWELL " " TO
FINISH SKIL STD. 2805 – WAX DIP
SCALE 1:1
DRN. BY H.G.M.
CKD. BY L.N
APP. BY E.F.E.
USED ON
P.E.O. 217-226
2740A – T1
REVISIONS
LOC.
A E.C. #6890 1-17-64 H.G.M. REDESIGNED
ADD HOLE LOC. & DIM.
E.C. #6937 2-5-64
B1 DIM. WAS ABOVE
B2 REMOVE .201 ±.003 DIA. (3 HOLES)
B3 ADD "(3 HOLES)"
B4 ADD DIM.
EC7244 6-12-64 T.U.
C1 OMIT HARDEN & TEMPER Rc 53-55
C2 ADD: INDUCTION HARDEN & TEMPER TO Rc 53-55 — 3/16 ± 1/16 AROUND DIA'S OF BOTH LARGE HOLES
DISTRIBUTION CODE 4 3 2 1 0
C2 INDUCTION HARDEN & TEMPER TO Rc 53 TO 55 — 3/16 ± 1/16 AROUND DIA'S OF BOTH LARGE HOLES
STAMP ARROW & LETTERING – LETTERING TO BE 3/32 HIGH SHARP FACE GOTHIC.
ROTATION
1" R.
60°
3/4 R.
32
.907 DIA. / .908
.125
.751 / .752 DIA.
1 1/2 R
3/8 R
1.375 ±.003
1 13/32
15°
.687 ±.003
.875 ±.003
1.758 ±.002
.257 / .256 DIA. (3 HOLES)
1.988 ±.003
6.040 ±.002
.199 +.0060 / -.0015 (1 HOLE)
.109 (REF.)
.340
80° +3° / -0° C'SINK (ONE PLACE)
6 41/64
NOTE:-
1 PLATE TO BE FLAT — WITHIN .010 LENGTHWISE WITHIN .002 CROSSWISE
2. NO BURRS PERMISSIBLE
SIMILAR TO 27911
DESTROY PREVIOUS PRINTS SEP 8 1964
LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIM. ± .010
DECIMAL DIM. ± .005
ANGULAR DIM. ± 30'
CONCENTRICITY BETWEEN
AND
T.I.R.

DIST CODE 9



PART NO. 27793

SKIL CORPORATION
CHICAGO, ILL.

PART NAME — PAWL & BEARING ASSEMBLY

MATERIAL — AS NOTED

SIZE —

LBS. PER 1000 PCS. —
FEET PER 1000 PCS. —

HEAT TREAT.

ROCKWELL ° ° TO

FINISH

SCALE	DRN. BY	CKD. BY	APP. BY
1:1	W.L.G.	L.N	E.F.E.
C.H.	12-3-63	12-18-63	12-18-63

217 - 234 MODEL Nos.

27908 -	T1				

REVISIONS

A	EC # 6890 1-22-64 W.L.G.
A1	OMIT 27181 AS REQ'D
A2	ADDED 1.015 - 1.016 DIA.
	ADDED 32 MICRO

DESTROY PREVIOUS PRINTS

DEC 22 1964

LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIM. ±
DECIMAL DIM. ±.±
ANGULAR DIM. ±.±°
CONCENTRICITY BETWEEN ▽ AND ▽ T.I.R.

REMOVE ALL BURRS

Exhibit E-2

ECL 93E

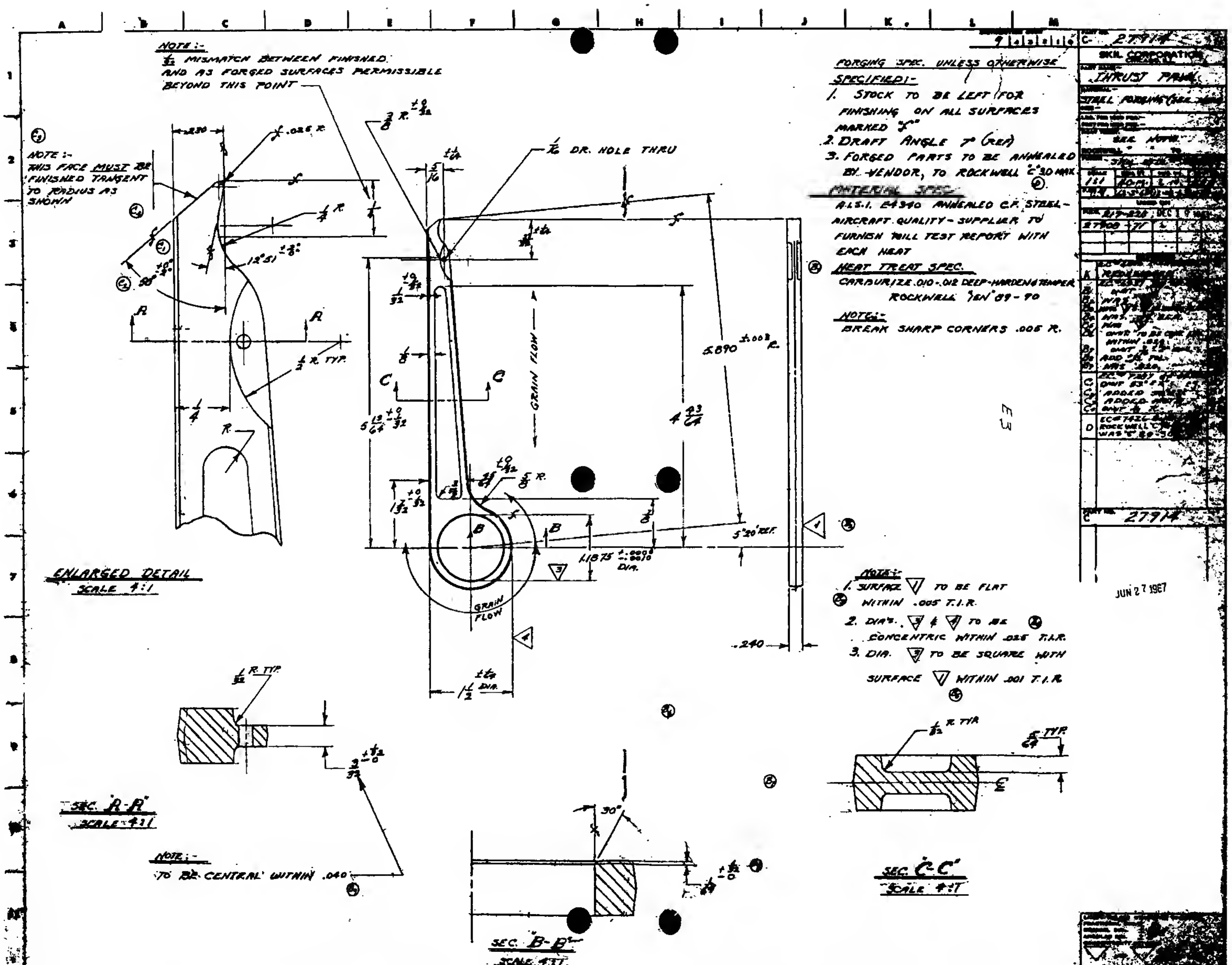
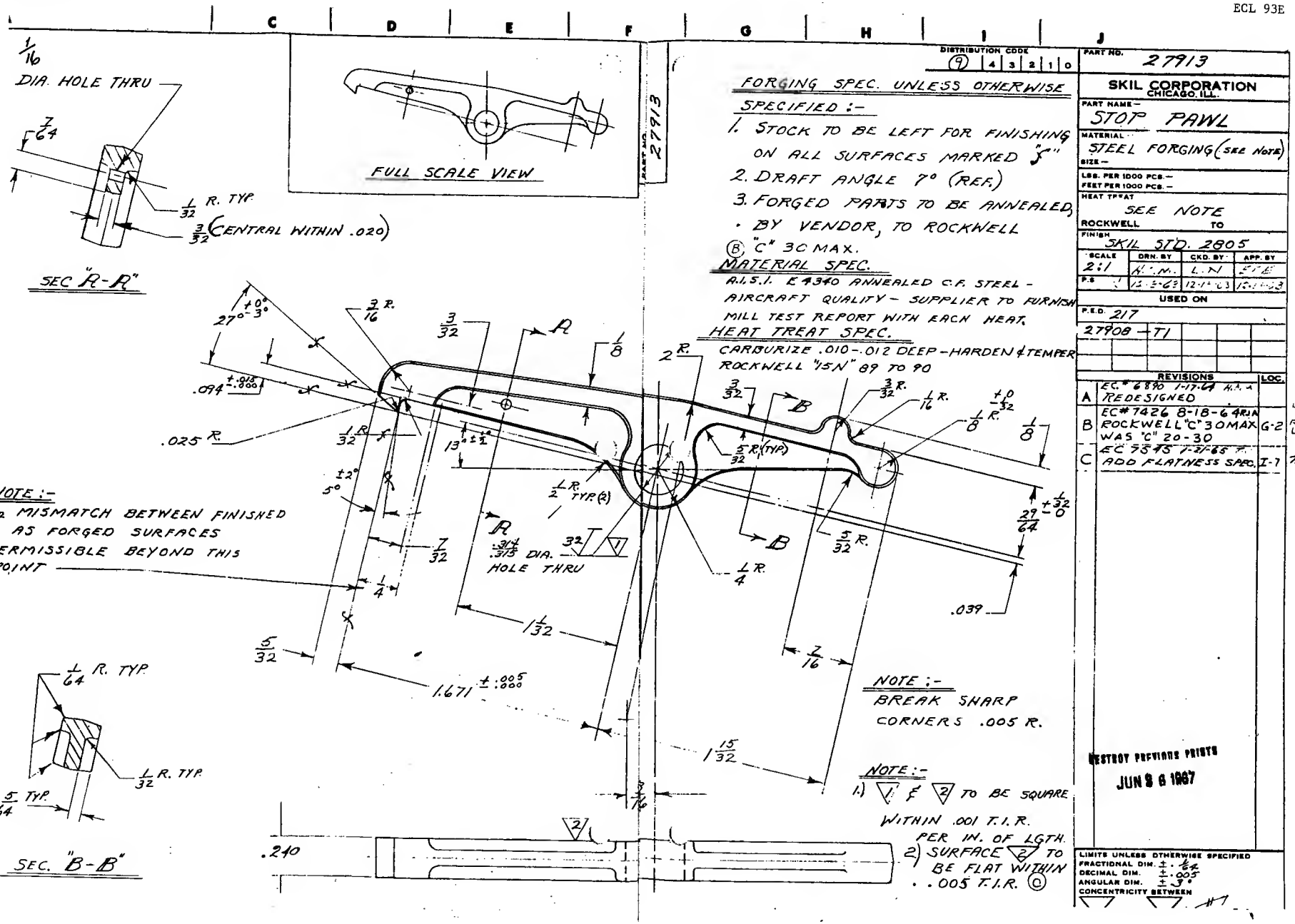
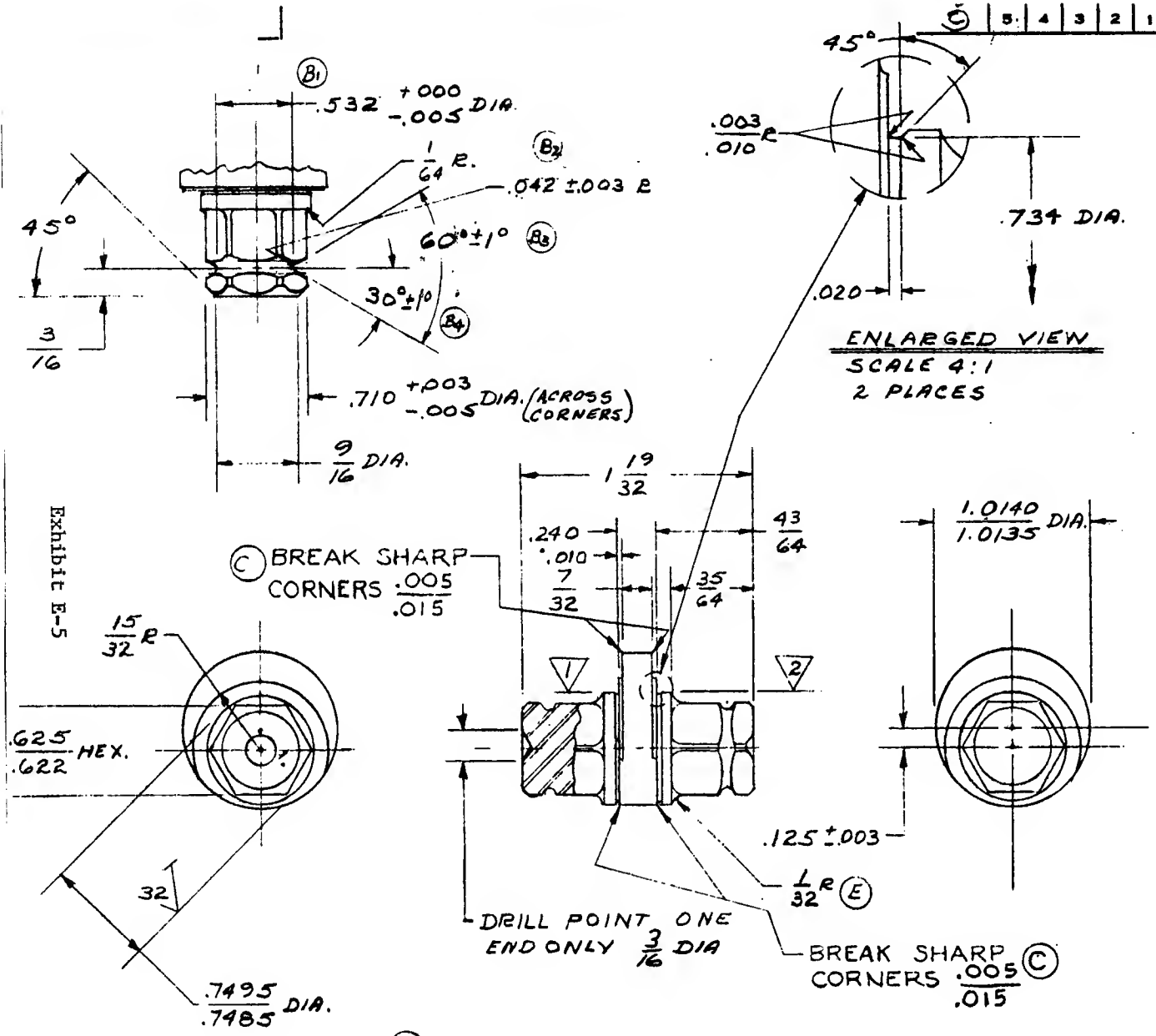

NOTE:- 1/32 MISMATCH BETWEEN FINISHED AND AS FORGED SURFACES PERMISSIBLE BEYOND THIS POINT
NOTE:- THIS FACE MUST BE FINISHED TANGENT TO RADIUS R3 SHOWN
1/16 DR. HOLE THRU
GRAIN FLOW
ENLARGED DETAIL
SCALE 4:1
FORGING SPEC. UNLESS OTHERWISE SPECIFIED:-
1. STOCK TO BE LEFT FOR FINISHING ON ALL SURFACES MARKED "f"
2. DRAFT ANGLE 7° (REF)
3. FORGED PARTS TO BE ANNEALED BY VENDOR, TO ROCKWELL "C" 30 MAX.
MATERIAL SPEC.
A.I.S.I. E4340 ANNEALED C.F. STEEL-AIRCRAFT QUALITY - SUPPLIER TO FURNISH MILL TEST REPORT WITH EACH HEAT
HEAT TREAT SPEC.
CARBURIZE .010-.012 DEEP-HARDEN & TEMPER ROCKWELL "15N" 89-90
NOTE:-
BREAK SHARP CORNERS .005 R.
NOTE:-
1. SURFACE 1 TO BE FLAT WITHIN .005 T.I.R.
2. DIA'S. 3 & 4 TO BE CONCENTRIC WITHIN .025 T.I.R.
3. DIA. 3 TO BE SQUARE WITH SURFACE 1 WITHIN .001 T.I.R.
SKIL CORPORATION
THRUST PAWL
27914
JUN 27 1967
SEC. "A-A"
SCALE 4:1
NOTE:- TO BE CENTRAL WITHIN .040
SEC. "B-B"
SCALE 4:1
SEC. "C-C"
SCALE 4:1
E3

Exhibit E-4

ECL 93E





D2 *OPTIONAL MATERIAL:
A.I.S.I. 4340 ANNEALED - COLD FINISHED
COMMERICAL QUALITY STEEL
(DH PROCESS PREFERRED)

5 | 4 | 3 | 2 | 1 | 0

27909

SKIL CORPORATION
CHICAGO, ILL.

PART NAME — ECCENTRIC SHAFT

MATERIAL — A.I.S.I. 4340 ANNEALED COLD FINISHED - AIRCRAFT QUALITY STEEL (DH PROCESS PREFERRED)
SIZE — 1 3/8 DIA.

LBS. PER 1000 PCS. —
FEET PER 1000 PCS. — MS 50472

HEAT TREAT.
HARDEN & TEMPER
ROCKWELL "C" 47 TO 50

FINISH
SKIL STD 2805

SCALE	DRN. BY	CKD. BY	APP. BY
1:1	W.L.G.	L.N.	
C.Y.	1-23-64	1-24-64	1-24-64

217-223 MODEL Nos.

27908 -	T1				

REVISIONS

A	EC# 6890 1-23-64 WLG. REDESIGNED & REDRAWN
B1	EC#7007 3-16-64 W.L.G. .532 WAS .535
B2	.042 ±.003 R. WAS .025-.030 R
B3	60° ±1° WAS 10° +2° -0°
B4	30° ±1° WAS 5° +1° -0°
C	EC 7244 6-12-64 R.L. ADD: BREAK SHARP CORNERS .005/.015 (2 PLACES)
D1	EC 7682 1-21-65 T.J. ADD MS 50472
D2	ADD OPTIONAL MAT'L
E	EC 7932 2-25-65 T.J. 1/32R WAS 3/32R

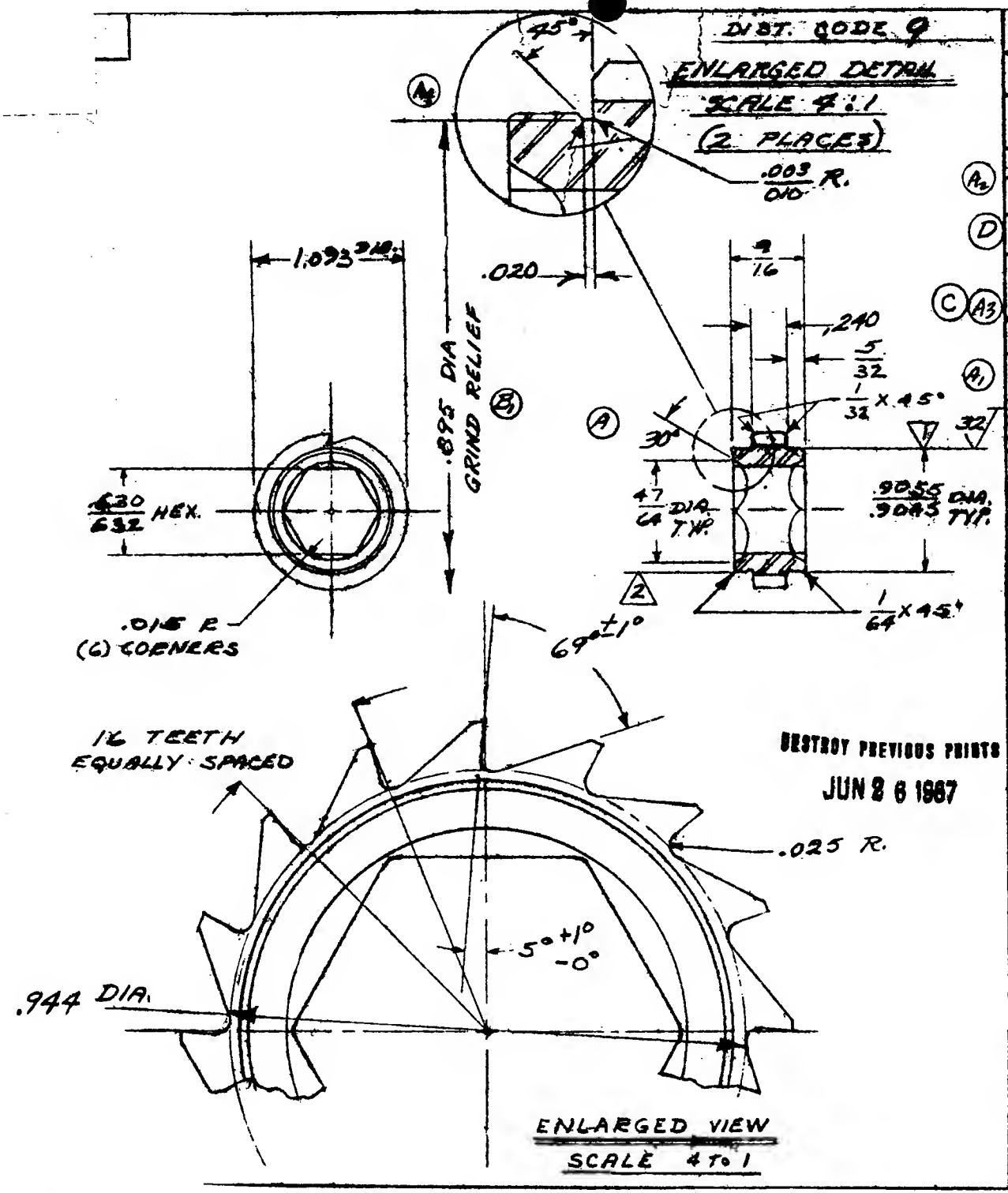
DESTROY PREVIOUS PRINTS

JUN 8 6 1967

LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIM. ± .010
DECIMAL DIM. ± .005
ANGULAR DIM. ± 3°
CONCENTRICITY BETWEEN 1 AND 2 .0015 T.I.R.

REMOVE ALL BURRS

ECL 93E



DESTROY PREVIOUS PRINTS

JUN 2 6 1967

PART NO. 27910

SKIL CORPORATION CHICAGO, ILL.

PART NAME — RATCHET

MATERIAL — A.I.S.I. E 6150 CRS FINISHED AIRCRAFT QUALITY STEEL (SH PROOF CONTROL)

SIZE — 1 1/4 DIA.

LBS. PER 1000 PCS. — MS 50470

FEET PER 1000 PCS. —

HEAT TREAT: CARBURIZE AND DEEP HARDEN & TEMPER.

ROCKWELL 15-N 86.5 TO 89.5

FINISH SKIL STD. 2806

SCALE	DRN. BY	CKD. BY	APP.
1:1	W.L.G.	L.N.	E.A.
CUT	4-18-63	12-18-63	3-19

217-224 MODEL NO. — TOOL

27908 -T1

REVISIONS

A	E.C. # 6290 PITCH 30° INCR 15°
A1	ADDED .005 FINISH
A2	MATERIAL WAS A.I.S.I. E6150
A3	ROCKWELL "C" 53 TO 56
A4	.9035 — ADDED .005 .010 GRIND REL. REMOVED
B1	E.C. # 6937 2-5-64 A.O.M. WAS .9035
C	E.C. # 7295 6-1-64 A.O.M. WAS "15-N" 89-90
D	DR 7607 10-29-64 R.L. EC 7991 3-19-65 A.W. ADD MS 50470

LIMITS UNLESS OTHERWISE SPECIFIED

FRACTIONAL DIM. ±.010

DECIMAL DIM. ±.005

ANGULAR DIM. ±3°

CONCENTRICITY BETWEEN 1 AND 2 .0015 T.I.R.

REMOVE ALL BURRS

ECL 93E

Exhibit E-6